

New Scientist

WEEKLY August 22 - 28, 2015

**WORKOUTS THAT
MAKE YOU SMARTER**

Tone your body,
tune your mind

SHOCK THERAPY

Saving birds by
electrocuting them

**PRINT YOUR OWN
SPACECRAFT**

Orbiting assembly line
awaits your orders

THE WRONG STUFF

Remix ordinary matter,
and very odd things happen



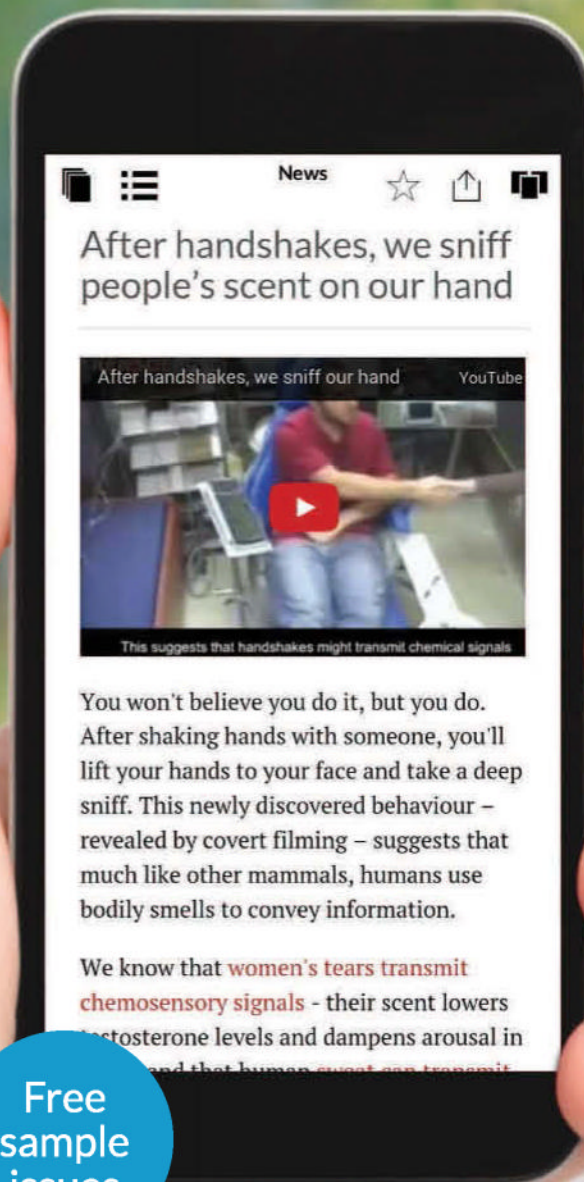
A QUESTION OF LIFE AND DEATH

Biology starts answering questions psychiatry can't

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ROB HAMMER/AURORA PHOTOS

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Syndication
Tribune Content Agency
Tel 800 637 4082

© 2015 Reed Business
Information Ltd, England.

New Scientist ISSN 0262 4079 is
published weekly except for the last
week in December by Reed Business
Information Ltd, England.

New Scientist at Reed Business
Information, c/o Schnell Publishing Co.
Inc., 225 Wyman Street, Waltham,
MA 02451.

Periodicals postage paid at
Boston, MA and other mailing offices.
Postmaster: Send address changes to
New Scientist, PO Box 3806,
Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a
newspaper and printed in USA by Fry
Communications Inc, Mechanicsburg,
PA 17055

A different way of thinking

Biological studies are revealing psychiatry in a new light, says **Thomas Insel**

A REVOLUTION is under way in psychiatry. The science underpinning this discipline has in the past shifted from psychology to pharmacology, and now it is changing again. We are starting to build it on genomics and neuroscience, thanks to advances in DNA sequencing and functional imaging.

The next decade should see all of these strands intertwined into a more holistic approach. People are beginning to recognise that depression and schizophrenia, for example, are brain disorders related to physiological changes rather than simply behavioural ones.

What does it mean to think of mental illnesses in this way? Is psychiatry really just part of neurology? Many disorders of neurology, such as stroke, involve damage to a specific site in the brain. But psychiatric disorders may be more usefully thought of as brain circuit problems – what researchers have called “connectopathies”. You could make an analogy with heart conditions. The behaviour and ways of thinking seen in a mental illness are symptoms of an underlying disorder in a brain circuit – a brain “arrhythmia”, but a straight neurological disorder would be more like a heart attack.

Teething problems

The problem is that even though there have been thousands of studies looking for biological markers of mental health problems such as depression or schizophrenia, none has proven clinically actionable. And, in truth, little has been replicable even in a research setting. So some psychiatrists understandably



AP PHOTO/CLIFF OWEN

PROFILE

Thomas Insel is director of the US National Institute of Mental Health and a member of the US National Academy of Medicine

reason that this approach offers no advantage, but large costs.

This is premature. Consider the recent history of cancer research. More than a decade ago, doctors realised that they needed to reconsider their diagnostic approach. Molecular genetics has revealed that tumours once labelled as “breast cancer” or “lung cancer” are actually many different forms. Traditional diagnostic criteria – such as what a tumour looks like or its location – lacked the precision to select the best treatment for each form. Better diagnosing information based on biomarkers is now allowing better treatment and prognosis for patients.

A similar process has just begun in psychiatry, with one of the vanguards being the US National Institute of Mental Health’s Research Domain Criteria (RDoC) project, which aims to collect genomic, cellular, imaging, social and behavioural information on large numbers of people with what are often termed “mental disorders”. Rather than trying to

map this on to the behaviourally defined categories that clinical psychiatry uses, RDoC will ask the data to define the categories, just as scientists have done with cancer. We already consider “depression”, “schizophrenia” and “autism” as more than single conditions; perhaps a decade hence, biological and other qualifiers will be essential to identify a specific condition and the best way to deal with it.

One example is recent work on suicidality. Researchers have found biomarkers for suicidal behaviour that seem significant across many of the current diagnostic categories of mental illness (see page 10). In addition, studies of psychosis, mood disorders and developmental disorders are beginning to deconstruct those groups by using biomarkers and innovative tests of cognition, which may prove to be the most powerful biomarker for such conditions.

Tectonic shift

Objective diagnostic categories that are reliable and biologically valid are long overdue in this field. For people under 50, psychiatric disorders cause more disability, have higher mortality rates and incur greater costs than any other group of disorders. If the path to better outcomes in cancer and other medical specialities requires precision medicine, then certainly the best hope for easing the morbidity, mortality and cost of psychiatric conditions will be to develop tests to identify precise diagnostic groups within what we now call mental disorders.

Such a tectonic shift could ultimately improve the lives of many millions of people. ■

Antibiotic crackdown

"NO, I'm sorry, but you'll get better without antibiotics." That's what family doctors in the UK are being told to say to those with minor ailments who demand the drugs. If they don't, the doctors risk disciplinary action that could culminate in them being struck off.

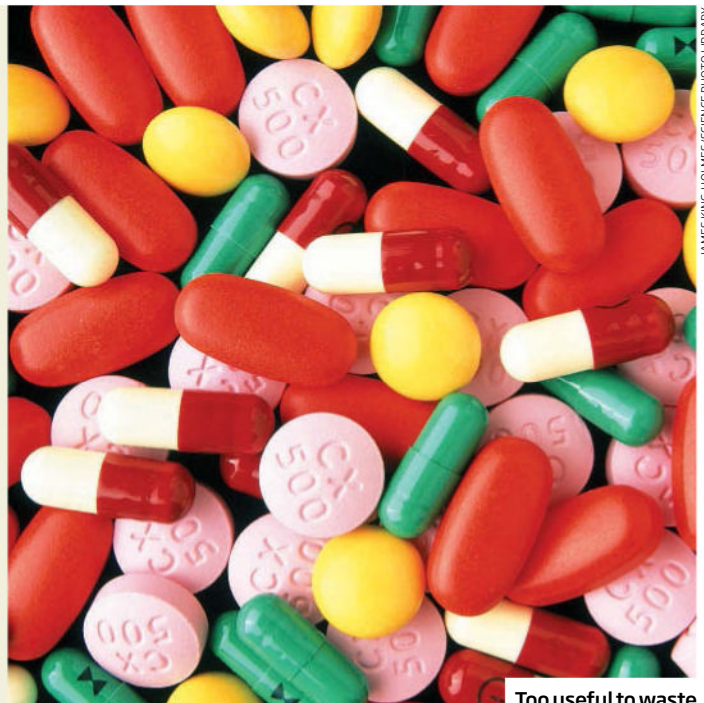
The move is part of a push by the UK National Institute for Health and Care Excellence (NICE) to cut antibiotic prescriptions. Of 40 million made in the UK last year, it estimates that 10 million were unnecessary.

The Royal College of General Practitioners says family doctors come under intense pressure from pushy people to prescribe antibiotics. NICE acknowledges this and says it plans to publish further material next year to help convince the public that

overuse of antibiotics imperils the future of medicine. Their overuse leads to bacteria becoming resistant, and the drugs ineffective. "The public have as much responsibility as any family doctor to understand that sometimes the doctor knows best," says a NICE spokeswoman.

If doctors who dramatically overprescribe continue to do so, they could face a referral to the UK General Medical Council, a body that censures doctors. However, this would remain the last option. "That's absolutely the end of the line," says the NICE spokeswoman.

The new guidance includes recommendations such as issuing "delayed prescriptions" that people are advised not to redeem unless a minor ailment lasts more than a few days.



JAMES KING-HOLMES/SCIENCE PHOTO LIBRARY

Too useful to waste

Comet milestone

#ROSETTAWATCH

HAPPY anniversary Rosetta. The European Space Agency (ESA) spacecraft recently completed its first year in orbit around comet 67P/Churyumov-Gerasimenko. On 13 August, it accompanied the comet at its closest approach to the sun, or perihelion.

"It's really a fantastic milestone that's been achieved by our Rosetta today," said ESA project scientist Nicolas Altobelli in a Google hangout to mark the occasion. It's the first time a



day you could fill 10 Olympic swimming pools," he says.

These watery outbursts take cometary material along for the ride. On 30 July the team observed a chunk, possibly 1 metre across, flying off the comet. "It's great to see this for the first time ever," says Sierks.

Perihelion has also changed the levels of different molecules streaming off 67P, says Joel Parker of the Southwest Research Institute in Boulder, Colorado.

Even at perihelion, 67P and Rosetta were still 186 million kilometres from the sun. For comparison, Earth gets about 40 million kilometres closer in.

The change in illumination as the sun switches sides relative to the comet means the team has been able to map its entire surface, including regions that were previously dark.

It's not all celebrations, though, as the mission team is still trying to make contact with the Philae lander. They have had no signal from it for more than a month now. "It is quite worrying for us," said Philae operations engineer Barbara Cozzoni.

"Every day you could fill 10 Olympic swimming pools with water coming off the warming comet"

spacecraft has monitored a comet up close as it moves from being dormant to heated activity.

Over the past year, the comet's surface has gradually warmed. The amount of water streaming off 67P has increased a thousand times since Rosetta's arrival, says Holger Sierks, who oversees Rosetta's main camera. "Every

Food shocks ahead

THE forecast for food looks grim. The risk of extreme weather events causing global "food shocks" is set to rise sharply unless we make our systems more resilient.

Climate change means that by 2050, crop failures linked to extreme weather that currently happen once in a century could instead happen every 10 years, according to a report from the UK Global Food Security programme.

The report is based on past observations, interviews with

experts, as well as climate and crop computer models. It finds that food production will become more variable. In addition, it says, there are "pinch points" in our transport systems, such as big ports and the Suez canal in Egypt, that could make any crisis worse if they were disrupted by extreme weather or instability.

"If the UK lost its east-coast ports because of a storm surge, we'd be in deep doo-doo whichever way you cut it," says Tim Benton of the University of Leeds, UK, one of the authors of the report.

Chemical catastrophe

WHAT caused the enormous chemical blasts that ripped through the Chinese port of Tianjin last week? On Tuesday, the Chinese government launched an investigation to find out.

The official chemical inventory of the warehouse where the fire started has yet to be recovered. Despite this, clues are emerging. Sodium cyanide has been found in water samples at almost 30 times the legally safe concentration. Calcium carbide, used in the manufacture of PVC, was

reportedly stored in the warehouse and could also be a culprit, says Joe Eades of Ispahan Engineering in Singapore. If it had been leaking, water from sprinklers turned on accidentally may have reacted with it to produce enough acetylene, a flammable gas, for a sizeable fire.

Eades says that ammonium and potassium nitrate, used in fertilisers, are also thought to have been there. These would have exploded when exposed to the blazing acetylene.

Switch off, kill pest

SPRAY away? Pesticides that work by tinkering with gene expression in the pest without modifying crop genes could get around regulations on genetic modification. The technology

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Celestial mountain caps are melting

Doomed glaciers

GLACIERS are disappearing faster than at any time since records began 100 years ago. Many of those in central Asia could be gone by 2050.

The Celestial mountains of central Asia, also called the Tien Shan range, have lost 27 per cent of their glacier mass since 1961, thanks to rising summer temperatures. They could lose a further half of what remains by 2050, according to research

on average 75 centimetres of their thickness each year (*Journal of Glaciology*, doi.org/6vq).

"The first decade of the 21st century saw the greatest decadal loss of glacier ice ever measured," says lead author Michael Zemp of the World Glacier Monitoring Service at the University of Zurich, Switzerland. "It's without precedent."

Museum raid

YOU won't find that in the gift shop. NASA is raiding retired space shuttles housed in museums for spare parts, with the intention of launching them to the International Space Station.

The last space shuttle flight was in 2011, and the four remaining shuttles were sent to museums around the US. This week, NASA engineers are removing four water storage tanks from the space shuttle Endeavour, which is currently housed at the California Science Center in Los Angeles. In May NASA took the same tanks from the space shuttle Atlantis, which is on display at the Kennedy Space Center in Florida.

NASA hopes the tanks could be combined into a water storage system for the ISS. "Using the shuttle tanks could greatly reduce the overall cost to build the new system," says NASA spokesman Daniel Hout.

"The first decade of 21st century saw the greatest loss of glacier ice ever measured"

by Daniel Farinotti of the Swiss Federal Institute for Forest, Snow and Landscape Research in Birmensdorf (*Nature Geoscience*, doi.org/6vp).

The impact on farmers could be immense, as meltwater from the glaciers supplies the Fergana valley, one of the largest irrigated areas on Earth. "It's like a huge water tower," says Farinotti.

An equally gloomy picture is painted by another study published this month, which looked at the fate of glaciers globally over the past century. The rate of melting has been accelerating, and in the decade from 2001 to 2010, glaciers lost



Apocalyptic aftermath

XINHUA/REX SHUTTERSTOCK

60 SECONDS

Islamic climate call

Islamic leaders from 20 countries are calling for the world's 1.6 billion Muslims to act on climate change, and for governments to phase out fossil fuels by 2050. The declaration was adopted at the International Islamic Climate Change Symposium this week and presents a moral case for fighting climate change based on Islamic teachings.

Gliding spiders skydive

Jungle spiders fall with style. *Selenops* spiders from Panama and Peru quickly adopt a stable posture akin to that of skydivers, and then use their forelegs to steer. It is the first time spiders have been seen gliding (*Journal of the Royal Society Interface*, DOI: 10.1098/rsif.2015.0534).

Smart mice are fearless

See how they don't run. Cat urine holds no fear for mice with disrupted production of a brain enzyme linked to bipolar disorder. And to boot, they are brainier, outperforming ordinary mice on standard cognition tests. The work could lead to drugs that reduce cognitive decline (*Neuropsychopharmacology*, doi.org/6vr).

Making CO₂ pay

Getting rid of the carbon dioxide in our atmosphere could be profitable. In a process described at this week's American Chemical Society meeting in Boston, the carbon from piped-in air was spun into valuable carbon nanofibres – the raw materials used to build strong composites such as those used in aircraft and sports cars.

Spanish mess

DNA in dog faeces could land owners in trouble in the Spanish city of Tarragona. Authorities are thinking of creating a DNA database of registered dogs to allow them to identify owners who fail to clear up. Such schemes already operate in some upmarket neighbourhoods in the US.

Print your own satellite - in space

Soon anyone could be an armchair astronaut, finds **Jacob Aron**

IT'S A Thursday night and you're bored, so you launch an app on your smartphone. A crisp view of Earth as seen from space pops up, and you start flying around. Moments later, your friend logs on and joins you in formation. But this isn't a video game – you're piloting a real spacecraft.

This vision is pie in the sky for now, but it could be possible in the near future thanks to efforts bringing manufacturing and consumer services to orbit, enabled by 3D printing, robotics and virtual reality. Welcome to 400 kilometres up, where business is booming.

"We want people to be thinking they can actually use space. It's

"We want people to think they can actually use space. It's not just for billion-dollar companies"

not just for governments and billion-dollar companies," says Brad Kohlenberg of Made In Space, a Californian firm building 3D printers for use in orbit.

Made In Space is on the crest of a wave of private companies trying to get consumer space technology off the ground. They launched their first printer to the International Space Station last year, where NASA used it to print a wrench from a design that was emailed from Earth. Later this year, the company plans to launch a more advanced printer that will allow anyone on the ground to build things in orbit.

The great advantage of manufacturing on the ISS is cutting down on launches, which are the riskiest part of any orbital endeavour. CubeSats – small, standardised satellites that have seen a boom in popularity in recent years – are used to do small



Assembled by astronauts

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experiments by everyone from governments to schoolchildren. They hitch a ride on rockets launching larger spacecraft, or get transported to the ISS on a cargo ship, where they are deployed by a robotic arm in one of the station's airlocks. But in the past year, three uncrewed rockets bound for the ISS have failed on launch, taking out dozens of CubeSats in the process. "Getting to orbit is an issue for them at the moment," says Greg Sadlier, space analyst at consultancy firm London Economics.

Made In Space has a solution specifically for CubeSats. Partnering with Texas firm NanoRacks, which helps deploy CubeSats on the ISS, the company plans to offer a service called "stash and deploy" that will allow customers to build in orbit starting in 2016. "The stash and deploy model could bypass the risk," Sadlier says.

The idea is to store many standard parts on the ISS, such as batteries, solar panels and sensors. When a customer places an order, Made In Space will print a plastic frame, and an astronaut will snap everything together before launching it out of the station (see "Building blocks", right). "We're developing technologies that can start pumping satellites out of a platform orbiting Earth," says Kohlenberg.

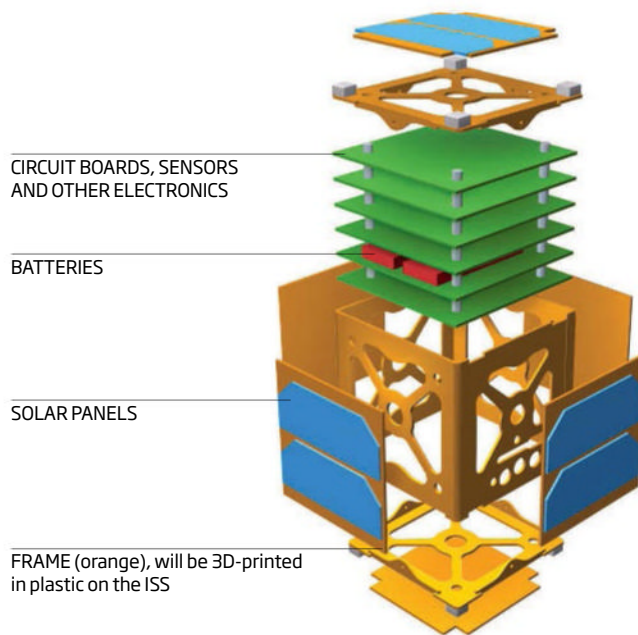
On demand

The strategy could also get CubeSats into orbit more quickly. Currently, owners have to wait to piggyback on the launch of bigger, more expensive spacecraft, which are often delayed. "Right now it's months to years after you've built something and have it ready to go to space," says Kohlenberg. Using 3D printing skips that wait. "You can imagine hackathons where people are designing spacecraft and have them operating in space over a weekend."

But space explorers are busy people, and can't spend all day

Building blocks

CubeSats are small satellites built from standardised parts. Private companies are planning to manufacture them in space, storing electronic components on the International Space Station and 3D printing the frame on demand



assembling satellites. So Made In Space and NanoRacks eventually want to build an uncrewed space station to manufacture satellites automatically. "When you look five years out, it's clear to me that with 3D printing and robotics, uncrewed platforms will be able to deploy on demand," says NanoRacks CEO Jeffrey Manber.

At the moment NanoRacks charges around \$85,000 to launch a CubeSat built on Earth, but automation and the ability to launch on demand should make the space-built kind much cheaper and create new possibilities. Customers could order a satellite to fly over and image an area just hit by a natural disaster, says Manber, but he also envisions more light-hearted services like beaming messages around the world.

Another Californian firm, SpaceVR, hopes to be the first to provide space-based entertainment to the public by putting a virtual reality camera on the ISS. It plans to sell a Netflix-

style monthly subscription to VR movies from orbit, viewable on a smartphone or headset. The goal is to give ordinary people a chance to feel the "overview effect" – the transformative experience that

"It would give ordinary people the transformative experience of seeing Earth from space in real time"

astronauts report after seeing Earth from space. "The idea is to bring that to everyone in a cost effective, scalable way," says CEO Ryan Holmes.

SpaceVR plans to send the electronics for its VR device to the ISS on a cargo ship, but will work with Made In Space to 3D print the housing in orbit. That means the camera as a whole doesn't have to be built to survive the stresses of launch, saving money on costly launch-proof materials like titanium. "It just made more sense to start manufacturing in space," says chief technology officer Isaac DeSouza.

Kohlenberg thinks others will find similar benefits once their satellite deployment platform is complete. "You can imagine spaceships and satellites the likes of which we have never seen, because you've always had to build for the launch vehicle," he says. "Now we can build whatever we want."

Holmes says SpaceVR also wants to develop a range of consumer products. "We are going to develop CubeSats that people can log in to and control from their computer or cellphone," he says. Squadrons of up to eight satellites could let you fly around with your friends and view Earth from space in real time, suggests DeSouza. "This is the next phase of space exploration," he says.

It remains to be seen whether consumers are truly ready to embrace space. Space VR is looking to raise half a million dollars on Kickstarter. "Space technology is quite esoteric, consumers don't know they want or need it yet because they don't understand what's possible," says Sadlier.

And before any of that, Made In Space and NanoRacks will need to demonstrate that they can successfully manufacture in orbit. Such mass production of small satellites will also raise concerns about space debris, and the possibility of *Gravity*-style collisions that could take out larger spacecraft. CubeSats orbiting Earth don't hang around forever, they lose altitude and burn up in the atmosphere fairly quickly, but the companies acknowledge it's something they need to take into account. "It's an issue that needs to be studied to make sure we don't start banging in to each other up there," says Manber.

Still, Made In Space and NanoRacks are confident their time has come. "It will be a surprise to someone in 2015 what we'll be able to do in space in 2020," says Manber. "We're finally at the start line, and it is going to be a very exciting couple of years." ■



Suicide in the blood

A blood test can reveal when people are thinking of killing themselves. This is groundbreaking news, but how useful will it be, asks **Sally Adee**

CAN you spot whether someone is likely to try to take their own life? In hindsight, it can seem obvious, but at the time, doctors and relatives rarely have much more than intuition to go on. Now a blood test could help doctors identify those most at risk. The idea marks a shift in diagnostic approaches to mental health, and has drawn criticism from some psychiatrists.

Nearly a million people worldwide take their own lives each year. Prevention efforts have done little to curb suicide rates in most countries, in part because

it is often so difficult to tell if someone is planning to do it.

Chemicals in the blood may provide a much-needed clue. Alexander Niculescu of Indiana University in Indianapolis and his colleagues have developed a questionnaire and blood test that together predicted with 92 per cent accuracy who among a group of 108 men receiving psychiatric treatment would develop suicidal feelings over the next year (*Molecular Psychiatry*, doi.org/6vk). Preliminary evidence suggests the test also works for women.

Because only about 16 in every 100,000 people end their own lives, a test with such a level of accuracy will give many false positive and false negative results if used on the general population. But it could prove useful for people who are already having psychiatric care, especially those who are addicted to drugs, incarcerated or have a family history of suicide, all of which

“Those who are serious about taking their own lives are least likely to reveal it or seek help”

are known suicide risk factors.

Although many factors like these are identified after a person kills themselves, none are predictive. While 90 per cent of people who kill themselves have been diagnosed with depression, only 2 per cent of people with depression kill themselves.

“Those who are serious about taking their own lives are often the least likely to reveal it and seek help,” says Gustavo Turecki at McGill University in Montreal, Canada.

A test that can spot suicidal intentions without relying on self-disclosure would help doctors to start preventative measures, such as putting someone on suicide watch. This typically involves preventing someone from leaving hospital, confiscating potentially hazardous items and continually monitoring behaviour. Research shows that suicide attempters can

be dissuaded from trying again, so the test might tell who could benefit from receiving such intervention before they have even tried to take their life.

To develop the test, over several years Niculescu's team took blood samples from 217 men undergoing various psychiatric treatments. They compared changes in gene expression in 37 of them who developed suicidal feelings with

categories defined by the *Diagnostic and Statistical Manual of Mental Disorders*, such as depression, bipolar disorder or schizophrenia, a system that has been criticised for relying on the subjective assessments of doctors rather than clinical tests.

While mortality linked to physiological conditions like cardiac disease has fallen, suicide rates are at an all-time high across all age groups in the US. In the UK, rates have been rising steadily since 2007, and similar trends are seen in other countries. The desire to have psychiatry benefit from biological advances in the same way as the rest of medicine is why the NIMH has changed its approach. But the shift towards detecting biomarkers by neuroimaging or monitoring gene expression has drawn criticism.

"The NIMH is funding biomarker porn," says James Coyne of University Medical Center in Groningen, the Netherlands. "It's airbrushed, heavily edited, and you can't replicate it at home."

Coyne's view is shaped by the small sample sizes used in early mental health biomarker research – something that can be problematic for rare conditions.

"It is extremely unlikely that a few genes are going to be able to predict risk for suicidality. It certainly won't in all cases," says Emil Coccaro of the University

"When someone comes to hospital with an injury or an overdose, it can be hard to tell if it was on purpose"

previously published work and with post-mortem samples of 26 men who had killed themselves. They identified 11 gene changes that could be biological markers for spotting people who might be considering suicide (see "Changing of the genes", right), and they monitored these same markers in a test group of 108 men with psychiatric conditions.

They combined the blood test data with an app that asks questions designed to detect suicidal intentions, and predicted with 92 per cent accuracy who of a group of men receiving psychiatric treatment would develop suicidal feelings over the following year – and with 71 per cent accuracy who would be hospitalised by an attempt.

"They were able to guess the future for hundreds of people," says Zachary Kaminsky of Johns Hopkins University in Baltimore, Maryland. "This is top-notch."

Linking biomarkers to mental health is a controversial topic. Since 2010, the US National Institute of Mental Health (NIMH) has been increasingly funding studies like these, which look for biological markers or changes in the body when someone shows certain psychiatric symptoms, regardless of what their psychiatric diagnosis might be.

This marks a move away from studies that use the diagnostic

CHANGING OF THE GENES

The activity of 11 genes seems to change when someone is thinking about committing suicide, according to work by Alexander Niculescu of Indiana University in Indianapolis and his colleagues (see main story).

Knowing the function of these genes could help us understand the biology behind this behaviour.

One of the genes is called *SKA2*, which indirectly affects the workings of the hypothalamic-pituitary-adrenal axis, a network of brain systems that is implicated in

impulsive and negative thoughts. When this gene's activity is turned down, the HPA axis becomes hyperactive, leading to runaway thoughts. Overactivity of this brain area has been repeatedly linked to suicide attempts.

Another of the genes, *SLC4A4*, is involved in regulating the pH of the brain, which has been linked to anxiety and panic attacks. It could be that in some cases, strong suicidal thoughts are similar to impulsive panic attacks, says Niculescu.

of Chicago. He is concerned that when biomarkers are used, other factors are ignored, such as what is happening in a person's life. Biomarkers may help you understand risk factors, but predicting subsequent behaviour is more difficult, says Turecki.

Hospital help

Niculescu's test has already proved successful where it would be used most – in hospitals. There, people are at a higher risk of suicide than the general population. Niculescu and his team found the test was especially predictive for people with bipolar disorder, predicting with 98 per cent accuracy which of them would develop suicidal thoughts, and with 94 per cent accuracy who

would make an attempt serious enough to require hospitalisation. "It could be used as a screening instrument," says Niculescu. "If somebody scored highly, they could be followed more closely, be hospitalised longer, their medications added or changed."

"It's really a groundbreaking study," says Bruce Cuthbert, who oversees the NIMH's push for biology-based diagnostics. He thinks a combination of an app and a blood test could be useful in emergency room settings – for example, to help determine whether an incident was likely to have been a suicide attempt. "Sometimes someone appears following an injury or an overdose," says Cuthbert. "Was it an accident or did they do it on purpose?" Emergency doctors often have very little to go on in making such a judgement.

Niculescu wants to extend his tests to the general public, but Kaminsky says the low rate of suicide in the general population would mean too many false alarms.

Regardless of whether these tests are used, the discovery of biomarkers is important for people who are suicidal but are dismissed by others as being lazy or lacking discipline, says Cuthbert. "It validates their sense that they have a real illness." ■



ED DARACK/SCIENCE FACTION/CORBIS

See also Leader, page 5



Big bird, big problems

California condor's shocking recovery

Penny Sarchet

IT SHOULD be hard to miss California condors – they are North America's largest birds, with wingspans of up to 3 metres. But lead poisoning from gun ammunition nearly drove them to extinction in the 1980s. Now, electric shock training and surgery are helping to re-establish these giant birds.

In the late 1980s, the last few individuals were taken from the wild to be bred in captivity. Since 1992, there have been multiple reintroductions to the wild, and there are now more than 150 flying over California and nearby Arizona, Utah and Baja in Mexico.

But to sustain themselves in the wild, condors have to survive for long enough to reproduce. Condors take five to six years to reach maturity, and usually don't successfully raise young until they have themselves been flying in the wild for seven years.

Electrical cables and lead poisoning have been killing them off too early. "As they go in to land

at a carcass, or to roost for the night, they just don't see the power lines," says Bruce Rideout of San Diego Zoo. Their wings can bridge the gap between cables, resulting in electrocution if they touch two lines at once.

So conservationists have come up with a shocking solution. The condors are caught several times a year for monitoring and health screening, when they also receive cable aversion training. Artificial

"As they go in to land at a carcass, or to roost for the night, they just don't see the power lines"

utility poles, placed in large training pens, teach the birds to stay clear of cables by giving them a painful electric shock. Before the training was introduced, 66 per cent of released birds died of electrocution. This has now dropped to 18 per cent (*Biological Conservation*, doi.org/6tb).

Lead poisoning has proved more difficult to deal with. When condors eat carcasses containing

lead ammunition, they absorb large quantities of the element. This affects their nervous systems and fertility, and can lead to kidney failure and death.

A partial ban on the use of such ammunition throughout the condor's range in 2008 seems to have had little effect (PNAS, doi.org/6tc). So condors with high levels of lead are sent to Los Angeles Zoo, where they are injected with calcium EDTA, a chemical that purges lead from the blood over several days. They may also get treatment to regurgitate ingested lead, and if necessary, surgery, says Myra Finkelstein at the University of California, Santa Cruz.

This work is starting to pay off. In 2000, the annual mortality rate for adult condors was 38 per cent, but between 2001 and 2011, this dropped to an average of 5.4 per cent – just shy of the 5.3 per cent thought to be needed for populations to become stable.

Rideout's team estimates that the California condors' average survival time in the wild is now just under eight years. "Although these measures are not sustainable indefinitely, they are essential for now," he says. "They are truly magnificent birds that are worth every effort we put into recovering them." ■

CO₂ could keep fracking's leaky side in check

SOMETIMES two problems can cancel each other out. Carbon dioxide emissions from power plants could be put to good use, preventing fracking chemicals from contaminating drinking water supplies.

Although fracking has unlocked new fuel sources and slashed energy prices, there is a risk that toxic compounds in the fracking fluid can get into shallow aquifers via fractures in the bedrock.

Andres Clarens at the University of Virginia in Charlottesville and his team say pumping CO₂ into the wells could prevent this. At the high temperatures and pressures found at depth, it reacts with silicate minerals in rocks to form a carbonate deposit.

In the lab, the team has mimicked conditions in the Marcellus shale, a vast hive of fracking activity beneath New York state and Pennsylvania. They found that half of the CO₂ injected in their experimental simulation was converted into solid carbonates within a day. The same would have happened to the rest before it could leak out to the surface, says Clarens, who presented the work this week at the Goldschmidt conference in Prague, the Czech Republic.

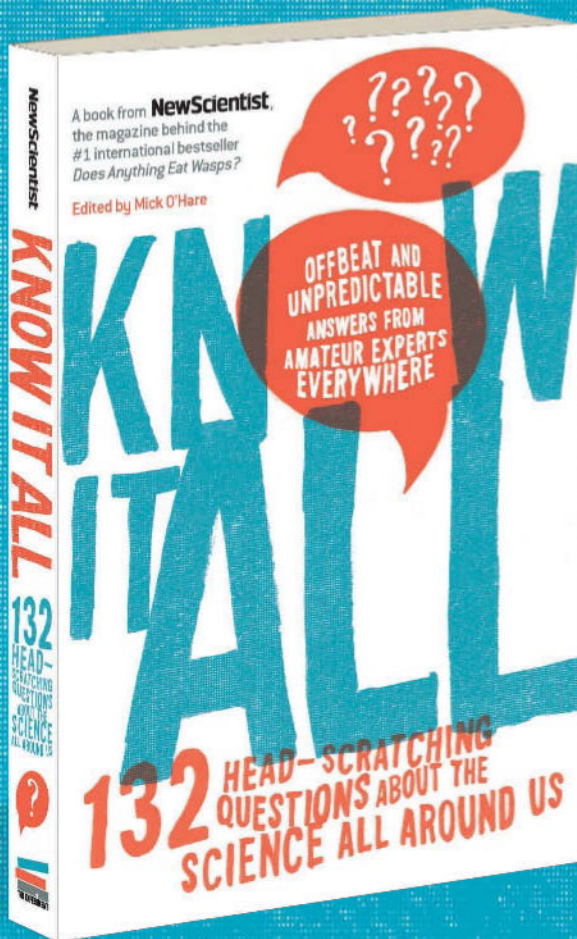
The technology for injecting CO₂ into rocks already exists, says Clarens, and models suggest that shale has an enormous capacity for storing it.

The idea is fascinating, says Richard Davies, a petroleum geologist at Newcastle University in the UK – but unnecessary. "Fractures rarely extend past a few hundred metres above the shale reservoir," he says.

But Clarens says fracking fluids could theoretically leak into aquifers, because the wells must be dug through shallow layers where the aquifers lie in order to reach shales.

"There is great potential for this technology to help improve the integrity of well bores," says Clarens. "I think that will go a long way toward improving public perception of fracking." Colin Barras ■

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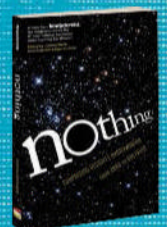
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Mass slaughter in Stone-Age Europe

Andy Coghlan

WHOEVER the assailants were, they probably arrived at dawn. Catching their victims unawares, they hacked the shin bones of as many villagers as possible to prevent them escaping, then bludgeoned them to death with blows to the head before dumping them in a mass grave.

Though no one can be certain what happened to the 26 people whose bodies were found in a Stone-Age mass grave, this is the most likely scenario, says Christian Meyer of the University of Mainz in Germany. His team analysed the bones, unearthed in 2006 at Schöneck-Kilianstädten, near Frankfurt.

He dates them to between 5207 and 4849 BC, in the Neolithic period, by which time farmers had spread through most of mainland Europe from the south-east.

The find is the third known massacre site from this period, and suggests that despite the popular image of peaceful harmony among Europe's

pastoral inhabitants, things sometimes got nasty.

Meyer says that evidence for individual cases of attacks and torture in ancient times have been found before, but that "this is the first time we have almost a complete village put to death in a mass grave".

The shin bones all bear evidence that the breaks were fresh when the people died. Half the victims were children and half adults, while the two oldest – who were aged over 40 – were the only women (PNAS, doi.org/6vm).

This area was the site of what were then the most advanced

"People may have been left starving and desperate enough to steal food - even if it meant murder"

human settlements. Previously, Europe had been populated by hunter-gatherers with few possessions who could resolve disputes simply by moving away.

The farmers were the first to invest heavily in permanent sites by, for example, clearing forests



A blow to the skull

and erecting buildings. This meant that unlike hunter-gatherers, they were seldom able or willing to avoid conflicts by leaving. "It was the first time in history our ancestors were faced with this problem," says Meyer.

The site of the massacre is on a border between two loose networks divided by differences in pottery and other artefacts found there – and so may have been targeted or raided by the rival network. The most likely trigger, Meyer thinks, is that crops failed, perhaps because of drought. This may have left people starving and desperate enough to steal food – even if it meant murder.

Peter Bogucki of Princeton

University says that without leadership structures beyond the group, conflicts were intensely personal and hard to defuse in those days. "There were probably codes of honour, respect and revenge that structured interactions, with the result being that things could get nasty quickly," he says.

Meyer says that injuries to the victims' skulls suggest they were killed by blows with an adze, a hammer-like tool. Custom-designed weaponry didn't show up until the Bronze Age 2000 years later. "It's disturbing and shocking that violence was also evident in Neolithic times," says Meyer. ■

Nice spiders fall first - and doom the silken reef

ON THE ecological battlefield, friendly spiders are the first to fall. A new study shows that the behaviour of individual animals can determine the fate of entire communities.

Most spiders are loners, but *Anelosimus studiosus* lives in forests of the Americas in colonies of up to 200 related individuals that build communal webs called silken reefs.

The reefs attract other spider species and some steal food and even

prey on *Anelosimus*. As a result, the colony usually collapses within a few years. But occasionally, the reef lasts longer, growing to several times the size of a large car and containing more than 50 spider species, says Jonathan Pruitt, an ecologist at the University of Pittsburgh, Pennsylvania.

Earlier, Pruitt and his team had shown that individual *Anelosimus* spiders have genetically determined "personalities". Some are aggressive, others more docile. Could these traits affect the fate of the colony? To find out, they created 30 lab colonies, starting with two docile or two aggressive spiders, and transferred them to a Tennessee forest, where



Welcome to spider city

they tracked them for seven years.

Colonies founded by docile spiders quickly accumulated other spider species, including some that harmed the colony. By contrast, colonies founded by aggressive spiders were better able to fend off other species at first (*Journal of Animal Ecology*, doi.org/5bt). "Eventually, they all succumb, but aggressives certainly make it for longer," says Pruitt.

The results sound a cautionary note for ecologists hoping to predict the fate of communities, says Daniel Bolnick at the University of Texas in Austin. "Individuals vary, and that matters in all sorts of ways for community ecology." Bob Holmes ■

E-spliffs - medicinal cannabis minus the high

Clare Wilson

IT IS the first time I've been sent cannabis through the post but I'm unfazed – I'm probably not doing anything illegal.

My delivery is a MediPen. It's an e-cigarette made using a strain of marijuana high in cannabidiol (CBD), the compound thought to give cannabis its purported medical benefits, and low in tetrahydrocannabinol (THC), the one that gets you high.

It's not the first low THC e-cigarette in the UK – a similar device called KanaVape has been on sale since last year – but MediPen is the first designed to give a high dose of CBD. It contains hemp oil imbued with 20 per cent CBD compared with KanaVape's 5 per cent.

Therefore puffing on this is more likely to deliver benefits – at least that's the claim. Researchers warn that there is no way to know for sure how much CBD any of these products contain, as they have not been tested under the same stringent conditions as licensed medicines. "There are a lot of claims but no proof," says Arno Hazekamp of Dutch firm Bedrocan, the only company in Europe that grows cannabis for medicinal use.

The idea is that vaping should make it easier for people to get hold of and use cannabis medicinally, for insomnia, or to relieve pain, for instance. Many don't want to get high or just dislike having to puff smoke. Some put the drug into food but that takes longer to work and it has more variable effects.

In Canada and 23 US states people can legally take cannabis for medical reasons and vaping it is becoming more popular. However, warning letters were recently sent out to the makers of 18 medical cannabis products by

the US Food and Drug Administration, which found many contained lower levels of CBD than advertised, with some containing none at all.

In the UK, the rules are stricter. The only approved cannabis-derived product is an expensive, under-the-tongue spray, called Sativex, prescribed for people with multiple sclerosis. MediPen offers a cheaper, non-prescription alternative, claims Sam Asante of the Cardiff-based manufacturer.

However, the makers of MediPen and KanaVape can't claim their products help in any specific health problems since they haven't carried out the necessary clinical trials. Instead, they rely on people being aware of the medical effects of cannabis, and putting two and two together.

Health claims aside, the devices are probably legal. Hemp products have long been sold in UK shops, as they are assumed to have no narcotic effects. A spokesman for the Home Office said CBD was not illegal as it was not psychoactive.

"Many people who use cannabis medicinally don't want to get high or dislike having to puff smoke"

This I can vouch for. I get no kick from it. Apart from the mint choc chip flavour, I can barely tell I'm inhaling anything but fresh air.

Pain specialist William Notcutt of James Paget University Hospitals in Great Yarmouth, UK, has a different gripe – that the health benefits are exaggerated. "It's being oversold," he says. "There are shops in LA where they say it cures ingrowing toenails."

At least CBD is unlikely to do any harm, says Notcutt, who consults for several makers of cannabis-based medicines. "The only way you could kill someone is by dropping it on their head." ■



No high anxiety



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New boson caught right-handed?

Michael Slezak

PHYSICS may be shifting to the right. Tantalising signals at CERN's Large Hadron Collider near Geneva, Switzerland, hint at a new particle that could end 50 years of thinking that nature discriminates between left and right-handed particles.

Like your hands, some fundamental particles are different from their mirror images, and so have an intrinsic handedness or "chirality". But some particles only seem to come in one of the two handedness

"If the Higgs is really a composite particle, that would mean new forces just around the corner"

options, leading to what's called "left-right symmetry breaking".

In particular, W bosons, which carry the weak nuclear force, are supposed to come only in left-handed varieties. The debris from smashing protons at the LHC has revealed evidence of unexpected right-handed bosons.

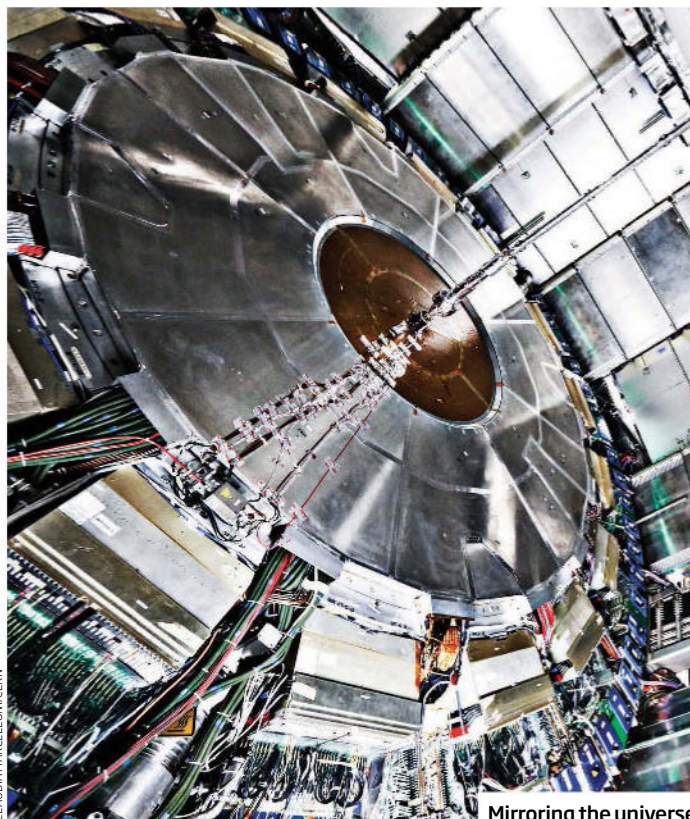
After finding the Higgs boson in 2012, the collider shut down for upgrades, allowing collisions to resume at higher energies earlier this year. At two of the LHC's experiments, the latest results appear to contain four novel signals. Together, they could hint at a W-boson-like particle, the W', with a mass of about 2 teraelectronvolts. If confirmed, it would be the first boson discovered since the Higgs.

The find could reveal how to extend the successful but frustratingly incomplete standard model of particle physics, in ways that could explain the nature of dark matter and why there is so little antimatter in the universe.

The strongest signal is an excess of particles seen by the ATLAS experiment (arxiv.org/abs/1506.00962), at a statistical significance of 3.4 sigma. This falls short of the 5 sigma regarded as proof of existence (see "Particle-spotting at the LHC", below), but physicists are intrigued because three other unexpected signals at the independent CMS experiment could point to the same thing.

"The big question is whether there might be some connection between these," says Bogdan Dobrescu at Fermilab in Chicago. In a paper posted online last month, Dobrescu and Zhen Liu, also at Fermilab, showed how the signals could fit naturally into modified versions of left-right symmetric models (arxiv.org/abs/1507.01923). They restore left-right symmetry by introducing a suite of exotic particles, of which this possible W' particle is one.

Another way to fit the right-handed W' into a bigger theory was proposed last week by Bhupal Dev at the University of Manchester, UK, and Rabindra Mohapatra at the University of Maryland. They invoke just a few



Mirroring the universe

novel particles, then restore left-right symmetry by giving just one of them special properties (arxiv.org/abs/1508.02277).

Some theorists have proposed that these exotic particles instead hint that the Higgs boson is not fundamental particle. Instead, it could be a composite, and some of its constituents would account

for the observed signals.

"In my opinion, the most plausible explanation is in the context of composite Higgs models," says Adam Falkowski at CERN. "If this scenario is true, that would mean there are new symmetries and new forces just around the corner."

The next step is for the existence of the right-handed W' boson to be confirmed or ruled out. Dobrescu says that should be possible by October this year. But testing the broader theories could take a couple of years.

Other LHC anomalies have disappeared once more data became available. That could happen again, but Raymond Volkas at the University of Melbourne, Australia, says this one is more interesting.

"The fact that the data hint at a very sensible and well-motivated standard model extension that has been studied for decades perhaps is reason to take this one a bit more seriously," he says. ■

PARTICLE-SPOTTING AT THE LHC

HOW DOES THE LHC SEE NEW PARTICLES?

It smashes protons together at practically the speed of light, fleetingly creating exotic particles. Analysing the collision debris can help identify them.

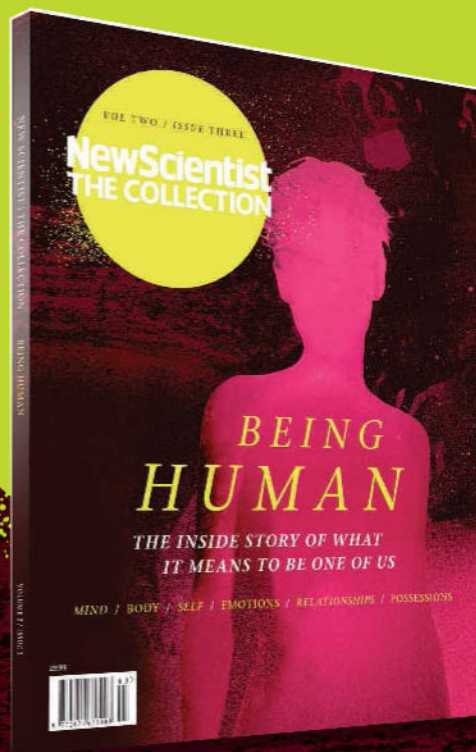
WHAT IS 3.4 SIGMA?

A sigma represents one standard deviation, a statistical measure of whether an observation is important or the result of random noise. Physicists have agreed that a particle is confirmed if measurements hint at

its presence with a "5 sigma" significance - indicating that the chance the signal is simply noise is one in several million.

WHAT IS THE W BOSON?

The fundamental particles are split into two categories: fermions and bosons. Fermions are things like quarks and electrons, which make up ordinary matter. Bosons, like the famous Higgs, carry the fundamental forces. The W boson is one particle that carries the weak nuclear force, which is involved in radioactive decay.

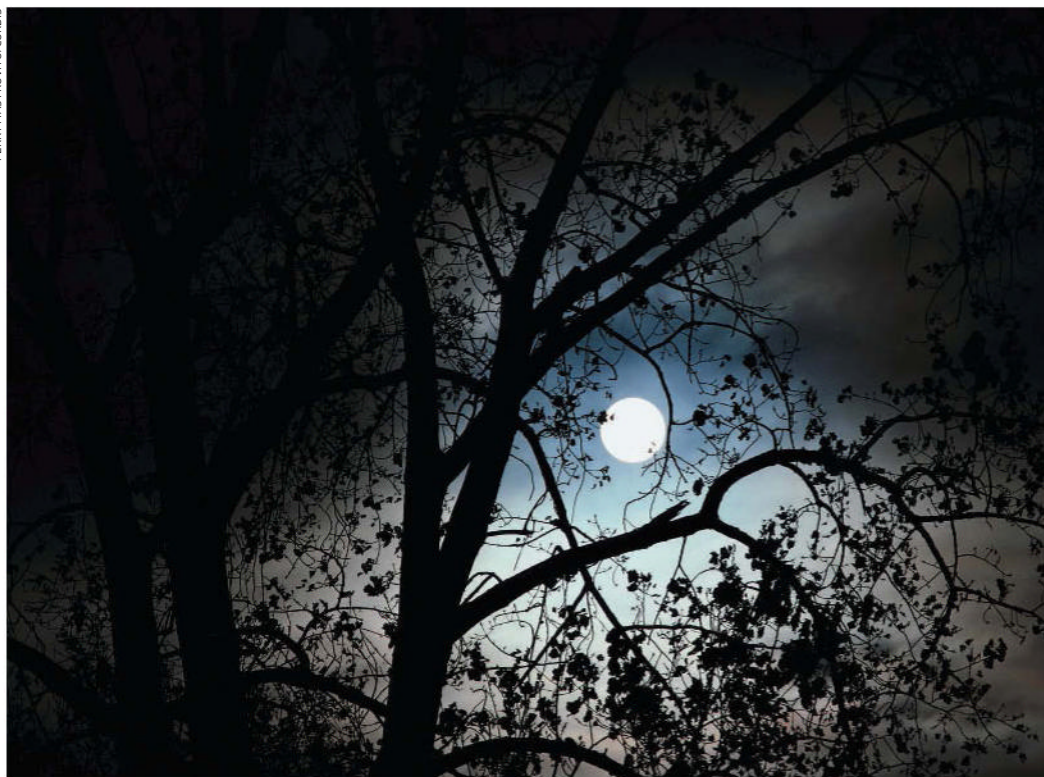


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Moon's gravity could pull plants to and fro

IT'S a drag. The movement of plant leaves may be partially governed by the gravitational pull of the moon, just like ocean tides.

Some plants' leaves rise and fall during the day-night cycle, mostly in reaction to light in their environment. But plants grown in the dark have similar cycles, which hints that something else may be at work as well.

Peter Barlow of the University of Bristol, UK, looked at data recorded since the 1920s on the leaf movement of beans and other plants. He matched these with estimates of the gravitational influence of the moon at

the time and location of these experiments.

The two data sets don't match exactly, says Barlow, but generally, when the lunar tide turns, so do the leaves. "If you look at enough of these correlations, they all seem to be strong enough to make you believe they might be causal," he says.

It's not clear exactly how the moon could influence this change, but it may be associated with the movement of water in a part of the plant called the pulvinus, the "joint" where leaf meets stem (*Annals of Botany*, doi.org/6tp).

"Scientific work on lunisolar impact on biological systems has sometimes been almost ridiculed," says Catarina Rydin of Stockholm University in Sweden, who discovered a plant whose pollination is governed by the full moon. "Papers like this are very important."

Superconductor hits record temperature

SUPERCONDUCTORS have just reached a new high. A material has been shown to transmit electricity with no resistance at the highest temperatures ever: the chilly conditions you might experience in Antarctica.

Mikhail Erements at the Max Planck Institute for Chemistry in Mainz, Germany, and his colleagues used a diamond anvil to squeeze a tiny quantity of

hydrogen sulphide to almost 1.6 million times atmospheric pressure. They found that it transformed into a material that superconducted at temperatures as high as -70°C , breaking the previous record of around -110°C (*Nature*, DOI: 10.1038/nature14964).

They're not sure why it works, but it could have to do with the material's light hydrogen ions,

which help electrons form pairs – a configuration that lets current travel more swiftly.

Erements hopes the new record will be beaten. There are a lot of materials to try which could have even higher thresholds, he says.

Superconductors can sustain a current indefinitely without an energy top-up, and finding ones that work at room temperature would spell a revolution in electronics. "Theoretically they are not forbidden," says Erements.

Whistle language uses whole brain

YOU could call it tweeting. An ancient form of "whistled" Turkish, which sounds like birdsong and is used to communicate across valleys, uses both sides of the brain.

Until recently, it was thought that language was mainly understood using the brain's left hemisphere. However, by testing 31 fluent whistlers, Onur Güntürkün of Ruhr University Bochum in Germany and his team have shown that this language – known to be involved in understanding music (*Current Biology*, doi.org/6vd).

"In all languages, tonal or atonal, click or sign language, written or spoken, it's so far been the left hemisphere that appears to do most of the interpretation," says Güntürkün. "Now, we have shown for the first time equal contributions from both hemispheres."

Star somersaults keep planets in line

MAGNETIC harnesses may keep planets in line with their stars.

Some exoplanets orbit at weird angles – instead of circling in the same direction in which their star spins, their paths are tilted, and sometimes even backwards. The mismatch seems to defy our understanding of how planets are born. Oddly, these misalignments only seem to happen to stars more than 1.2 times the sun's mass.

Now Christopher Spalding of Caltech argues that smaller stars' planets line up with their spins because those stars have stronger magnetic fields. As its solar system forms, the star's fields grab charged particles in the planet-forming disc and pull the star into the disc's plane (arxiv.org/abs/1508.02365).

Disco clam is ah ha ha stayin' alive

FOR disco clams, the party never stops. Their mesmerising light show makes it look as if there are lightbulb-like filaments flickering on and off inside their shells. The clams perform their flashy display more or less constantly on the reefs in the Indo-Pacific where they live, says Lindsey Dougherty at the University of California in Berkeley.

She found that they use their mantle – a thin membrane around their body inside the shell – to reflect ambient light in their environment. One side of this mantle is coated in silica that catches the light, so the clam seems to produce brilliant flashes as it furls and unfurls it.

“What everyone really wants to know is why they are flashing,” says Dougherty, who will be discussing the phenomenon at a meeting of the American Malacological Society in Pellston, Michigan, later this month. “Unfortunately it’s a really difficult question to answer.”

Her team has found that the light show isn’t used to communicate with other clams or to attract plankton to eat. Instead, the clams may be trying to put off predators. But predation events are rarely seen, so finding evidence is hard.

Dougherty hopes to identify aggressors from signs of attack on old shells she has collected, and introduce these predators to clams in the lab to see what happens.



Oldest human hand hints at early descent from the trees

THE discovery of a 1.8-million-year-old pinky bone suggests that modern human hands, good at tool use but bad at tree climbing, evolved earlier than we thought.

The bone found in Tanzania’s Olduvai Gorge is the earliest modern-human-like hand bone ever found, and pushes back the origin of our dextrous digits by some 400,000 years.

The find suggests that by 1.8 million years ago, a *Homo sapiens*-like species had already made the transition to terrestrial living, and coexisted with smaller, more tree-

dwelling *Homo habilis* and *Paranthropus boisei*.

“This bone belongs to somebody who’s not spending any time in the trees at all,” says Manuel Dominguez-Rodrigo from the Institute of Evolution in Africa, in Madrid, whose team analysed the bone. Hanging from branches bends bones like this one that extend from the knuckle, whereas in modern humans – and in this case – they are straighter (*Nature Communications*, DOI: 10.1038/ncomms8987).

“This provides good evidence

supporting the hypothesis that, by about 2 million years ago, our early ancestors lost the anatomy linked to our tree-climbing past,” says Brian Richmond of the American Museum of Natural History in New York.

But Richard Potts of the Smithsonian Human Origins Program in Washington DC says that a single bone is not enough to conclude that the hand it came from truly resembles that of a modern human, even though it is clearly different from those of the ape-like Australopithecines.

Blind mice run off after gene therapy

WHEN the owl swooped, the “blind” mice ran away. A new type of gene therapy had reprogrammed cells in their eyes to enable them to sense light.

The treated mice ran for cover when played a video of an approaching owl. “They reacted to the owl in the same way as sighted mice, whereas the untreated mice didn’t do anything,” says Rob Lucas of the University of Manchester, UK.

This is his team’s best evidence yet that injecting the human gene for the pigment rhodopsin into the eyes of blind mice can help them see real objects again. The pigment enables nerve cells deeper in the retina to sense light for themselves (*Current Biology*, doi.org/6t8).

Unlike in previous studies, these mice could see objects at normal light levels rather than just under extremely bright light.

The approach aims to treat all types of blindness caused by damaged or missing rods and cones – the eye’s light-receptor cells. Most gene therapies for blindness so far have focused on replacing faulty genes in rarer, specific forms of inherited blindness.



Why some kangaroos walk on all fives

HIGH fives all round? Some kangaroos use their tail as a fifth leg to help them get around.

Kangaroos and their cousins hop when they need to move quickly, and the longer their back legs are, the faster they can go. At slower speeds, they lean over and use their arms too, in a kind of jumpy-crawl, and that’s when many species use their tail as a fifth leg. However, not all species do this, and no one knew why.

So Rebekah Dawson from the University of Western Australia in Perth and her colleagues examined walking in 16 species. They found

that only animals whose legs are long relative to their body size co-opt the tail as a fifth leg, but it also depends on the habitat of each species.

All of the “five-legged” species live in open forests and grasslands. Those with the standard four inhabit denser forests and hilly areas. That’s probably because long legs are more important in open areas to escape predators, whereas manoeuvrability matters more in forests (*Australian Journal of Zoology*, doi.org/6s3).

This “nicely resolves a considerable puzzle”, says Terry Dawson of the University of New South Wales.



My app will be contesting that ticket

Don't park your outrage

Online tools are making it far easier to challenge decisions, generate campaigns and resolve disputes, finds **Aviva Rutkin**

IT WAS winter in California. Eric Schoffstall, a software developer in San Francisco, was driving through one of the state's national parks when he found that the road ahead had been closed for the rest of the season – because of snow.

Except that California was and is in the middle of a drought, and there was no snow in sight. The road, Schoffstall figured, had been shut simply as a matter of routine.

"It really bugged me," he says. He wondered whether he could fake public outrage around the issue, without wasting much money or time. "I started thinking about how I could automate making my voice heard."

As a test, Schoffstall picked a smaller battle: light pollution at a park near his apartment. He used Amazon's crowdsourcing marketplace to solicit fake complaints, offering 20 cents for

each one received. The responses rolled in, some surprisingly specific, referencing local political history or relating personal tales of woe (see "Those lights ruined my romance", below).

One of the responses criticised Schoffstall's strategy: "Writing fictitious complaints to the government is never a good idea." Undeterred, he sent a few of the

other responses to the neighbourhood association and the city's parks and recreation department. A few weeks later, the park lights had been fitted with guards to block upward beams.

With a little technological know-how, Schoffstall had found that he could amplify his own indignation. "The automation potential for this is shocking,"

THOSE LIGHTS RUINED MY ROMANCE

When Eric Schoffstall asked people on the Amazon Mechanical Turk platform to pen complaints about light pollution in a park, he had 20 responses in 2 hours. Workers spent an average of 5 minutes 25.5 seconds on each one – and they were nothing if not inventive:

- "I've already had to take two sick days off of work because I have been

unable to rest properly at night due to this outrageous amount of light pollution."

- "I heard one of my neighbours talking about taking the lights down himself! He is no electrician and could get himself hurt."
- "My late-night romance has been ruined because of these bright lights!"

he says. "Look at corporate lobbying. You could bring that power into anyone's hands."

That will alarm many, like the respondent who took Schoffstall to task. But automation need not involve seeking the backing of the masses.

In certain US cities, drivers who receive a parking ticket can snap a picture of it and upload it via the apps WinIt, Cited or Fixed.

"With a little technological know-how, he could artificially amplify his own indignation"

Software identifies information like the ticket ID, and scans the details for errors or cross-references them against other sources, such as the street labels on Google Maps. Then human experts look the case over and, if a defence can be made, contest the fine on the driver's behalf.

The service saves people the time and hassle of trying to make sense of complicated parking regulations, says Christian Fama, one of WinIt's founders. "People don't know what the defences are. There's nuanced stuff that, unless you're an expert, you might not know to do," he says.

Meanwhile, in Los Angeles, citizens irked by the many helicopters in local airspace have pushed for their complaints to be heard by the US Federal Aviation Administration. Enter the Automated Complaint System, which the FAA launched in April. People bothered by a specific helicopter can now call a hotline and answer a series of recorded questions, or go online and spot the copter on a live map. The system automatically records where each helicopter was spotted, which company was flying it and for how long.

David Garfinkle of the Los Angeles Helicopter Noise Coalition says that the system has made it easier and faster to register complaints – so far, it has collected about 6000 of them.

Over time, it will help quantify the problem and highlight the noisiest offenders.

But as it gets easier for people to register their grievances, it may get harder for the authorities to process them, says Harry Surden, a professor at the University of Colorado Law School in Boulder.

"Maybe those barriers were serving a societal purpose, making it hard enough that only people who really cared about an issue were able to complain," he says. Traditionally, most people didn't contest parking tickets. With the new software, it's possible the authorities will be overwhelmed by a sudden influx of cases filed by proxies.

Digital judgements

Perhaps the solution is for dispute resolution itself to be partly automated. Auction site eBay and internet payment system PayPal rely on a San Jose company called Modria to handle most disputes between users. Modria's platform collects details of the transaction, checks them against the rules in its system, and then spits out a judgement.

Such a model could also work for cases that tend to follow predictable patterns, such as disputes between landlords and tenants, says Daniel Martin Katz at the Chicago-Kent College of Law. "In these digital courts, it turns out there's an 80/20 rule: 80 per cent of the disputes are pretty simple and easy to deal with," he says. "Eventually, you make it to a human, but before that there's a lot of stuff that can get resolved with little human involvement."

It may be a long time before real-world courts come around to the idea. In the meantime, people like Schoffstall will continue to take their issues into their own hands.

"The end goal for me is to just get that road open," he says. "If I could work my way up to that, I'd be pretty happy about it." ■

Eavesdropping app makes phone your PA

YOUR phone is listening to you. A program that runs in the background of your smartphone can digest and understand the sounds of the world around it. The information it gleans could inform the next generation of virtual assistants. It could also make search engines far more useful.

Neural networks - computer models that ape the complexity of the brain - dominate our online lives: Google Translate can whip English text into Russian, for example, while Facebook's DeepFace can pick one face out of millions.

Now that power is moving offline. Nic Lane and colleagues at Bell Labs in Murray Hill, New Jersey, have built a listening neural network called DeepEar that runs on a phone without being connected to the internet.

The idea of continuous audio sensing isn't new, but until now the algorithms haven't worked well in a noisy environment. They were also too power hungry. Lane's system uses about 6 per cent of a smartphone's battery for a whole day of listening.

DeepEar works by training a neural network to listen for and recognise different kinds of aural scenes,

identify human speakers, recognise emotion and detect stress. In the roar of a busy train station, for instance, DeepEar might be able to hear the time of the next train announced over the PA system, as well as the emotion in its owner's voice as they argue with a slow ticket-seller. That information could help software assistants learn to remind the phone user to arrive at this particular station with plenty of time to spare in future.

"This means a very responsive virtual assistant that can understand both you and your environment and respond to you immediately," says Dimitrios Lymberopoulos at Microsoft Research in Washington State.

"The system is trained to identify individual human speakers, recognise emotion and detect stress"

"This experience could make virtual assistants way more useful."

Unlike the major commercial neural networks, DeepEar doesn't rely on powerful computers accessed via an internet connection to do its heavy lifting. Instead it uses only the

processors in a smartphone. This saves battery life and keeps the user's personal information on their own device rather than in the cloud.

It's not just audio that offline neural networks are targeting. Earlier this year, Lane and colleagues built a prototype device designed to capture high-resolution lifestyle data from wearable sensors. The system, worn on the lapel, could make inferences about what the person was doing by interacting with sensors such as FitBits. It also listened to the wearer's voice to detect issues such as stress.

Lymberopoulos says endowing mobile devices with the ability to continuously analyse data allows them to understand the environment someone is in, and adjust their interface accordingly.

"Because of the ubiquity of mobile devices and the robustness and accuracy of neural networks, we could use these systems to understand the physical world and index it in real-time," says Lymberopoulos.

He also envisages adding the findings of neural nets like DeepEar to search engines, letting us search for cafes by ambience, for instance.

"Right now, there is no search engine that can understand what a 'crowded bar' or a 'bar playing loud pop music' is. With this type of sound classification, we can make this real," he says. Hal Hodson ■



Listening in

ANDREW KELLY/REUTERS

Rise of the AI sports coach

Winners need good data – software can help, says **Chris Baraniuk**

WHO really calls the shots in team sports? The players? The coach? Maybe it could be a computer.

Software analysis of the passing strategies of teams in the Spanish football league during the 2013-14 season has given a unique insight into how they play. It's one of a raft of artificial intelligence tools that are giving coaches a deeper understanding of the game.

The software analysed video of 300,000 passes made across the season and identified hundreds of patterns used by the teams.

"We were curious about whether it was possible to distil some of the tactics of the team from the trajectory of the ball," says Laszlo Gyarmati of the Qatar Computing Research Institute.

Sure enough, the algorithm revealed that Barcelona and Real

Madrid had over 100 recurring passing patterns – 151 and 180 respectively. There were surprises, too. Atlético Madrid, which won the league that season, had just 31 recurring patterns (arxiv.org/abs/1508.02171).

Stefan Szymanski, a professor of sport management at the University of Michigan, says this lack of predictability could be why Atlético Madrid were successful.

"If I were a club I might even say we don't want more passing patterns, we want fewer patterns," he says. "What makes Messi the greatest player on the planet is you just don't know where the hell that guy is going next."

The biggest teams are already investigating how data analysis can help improve their game. Bayern Munich and Hoffenheim,

for example, recently partnered with German software giant SAP to gain detailed performance assessments after each match.

SAP's system uses machine learning to comb through match data. But it also incorporates manually annotated comments from analysts, so it can begin to understand the data in the way that a human coach might.

Other team sports can benefit too. In Finland, a start-up called

"Atlético Madrid had just 31 recurring passing patterns, a lack of predictability that made them so successful"

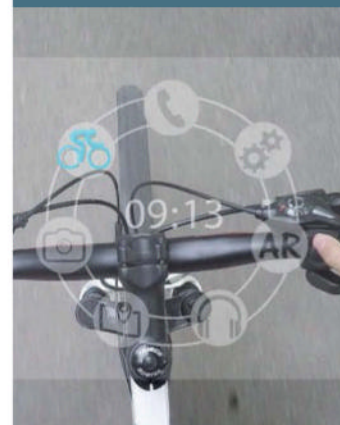
SportIQ has developed wearable devices for ice hockey players and a connected puck that communicates location data to radio receivers set up in stadiums. CEO Harri Hohteri says the system is able to pick out tactical insights during the game. He is hoping to get approval from the Finnish ice hockey league for professional teams to use SportIQ's technology in the upcoming season.

In the US, another firm – Second Spectrum – has created a pattern recognition system for basketball. This learns the positions of the players and types of play. "Almost every single contender for an NBA championship this year is using our software," Second Spectrum CEO Rajiv Maheswaran told a TED talk in March.

American football is also getting in on the act. Alan Fern at Oregon State University has worked on a project to develop AI for match analysis. He says computers still need to get better at picking out the patterns worth flagging to coaches. But he believes they have great promise.

"I think this will definitely revolutionise sports," Fern says. ■

ONE PER CENT



Augmented ride

Get ready to upgrade your cycle ride. Chinese start-up InSenth is developing augmented reality glasses specifically for use while cycling. Arrows projected onto the road avoid the need for a map, and the glasses display relevant statistics such as speed, distance covered and calories burned. They also have an inbuilt camera. InSenth is crowdfunding the development of the glasses, and has almost met its \$40,000 goal.

650

The number of times US pilots have seen drones while airborne this year. There were only 214 sightings in all of 2014, according to the Federal Aviation Administration

Apple's self-drive car

Apple or Android? We're all familiar with making this choice for smartphones, but it's about to take on a new meaning. A public records request by *The Guardian* newspaper in London confirms that Apple is working on an autonomous car, following in Google's footsteps. The firm aims to test its Project Titan vehicles at the GoMentum facility in Concord, California, which is specially designed for the purpose.



Be unpredictable to win



A career in science, it's not always what you think

From movie advisor to science
festival director, where will your
science career take you?

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Tar muchly

TIME for a moment of reflection. This image of a solitary pumping boat, sailing on the still waters of an artificial lake in the Canadian province of Alberta, was taken in 2013 by the Canadian photographer Louis Helbig.

The serenity of the landscape disguises its colossal economic value. Stretching over 93,000 square kilometres under this part of Canada is the Athabasca oil sands, one of the largest deposits of crude oil in the world and the principal source of petroleum for the US.

The oil is found in the form of bitumen, a thick black liquid whose resemblance to tar means the terrain is sometimes referred to as tar sands. Once extracted from the ground, the bitumen needs to be purified in ponds such as the Syncrude Southwest Sand Storage, pictured here. "What is mind-boggling is the scale of this enterprise," says Helbig.

Each dot on the water's surface is a scarecrow called a "bitu-man", intended to dissuade birds from diving into the toxic water and saving them from the oily surface coating that enhances its reflectiveness.

Helbig has been chronicling the changes caused to this part of Canada by the petroleum industry since 2008. In late 2014 he released *Beautiful Destruction*, a book containing more than 230 of his photographs of the oil sands, alongside essays presenting a spectrum of views on the future of Alberta's mining industry. "My role as an artist is to create a space where people will begin to imagine and reflect," says Helbig. Gilead Amit

Photographer

Louis Helbig

beautifuldestruction.ca

Don't let fear win

Deep distrust of nuclear energy must be addressed in order to realise its potential to power the future, says **Geraldine Thomas**

WHEN atomic bombs destroyed Hiroshima and Nagasaki 70 years ago this month, the nuclear age began in truly shocking fashion. From this shadow emerged the peaceful application of nuclear technology to generate electricity.

Nuclear power continues its slow spread today, a high-tech, low-carbon way to produce energy at a time when curbing emissions is a priority. And yet the degree of public anxiety over nuclear power seems frozen in time, owing more to 1945 than anything since.

The fears far outweigh the risk. This industry has seen only a handful of serious accidents. Fear persists because of the long-term health effects that radiation can cause, such as cancer. This is what concerns the public most.

Even though our knowledge of the effects has greatly increased, one major gap remains, and it helps fuel the worries. There is



a dose-response relationship for all toxic substances we are exposed to, including ionising radiation.

The problem is the shape of that relationship. At present, we assume radiation effects scale linearly with the dose size, as we don't have, and may never have, the evidence to disprove this. This results in the conclusion that no dose of radiation is safe.

However, a paper in *The Lancet* focusing on the 2011 accident at Japan's Fukushima Daiichi power plant, which followed the Tohoku earthquake and tsunami, suggests that measures to protect against low radiation doses with an indefinable health risk may create an even greater health risk.

The psychological harm and stress of measures such as long-term evacuation can kill. For example, mortality among those moved from nursing care in the area around Fukushima increased

Fat unlimited

The obsession with fat intake needs to end, say **Dariusz Mozaffarian** and **David Ludwig**

FOR decades we have been fed official limits on the total fat in our diets. It's time that ended, a position we have summarised in the journal *JAMA* (doi.org/6s2).

Dietary policies have long emphasised limits. In 1980, the US recommended that no more than 30 per cent of daily calories should come from fat. The World

Health Organization and many countries followed suit.

In place of fat, we were told to eat more carbohydrates. People and industry took the message to heart, and fat-reduced products followed – often rich in refined starch, added sugars and salt.

But by 2000, growing research showed benefits from healthy fats,

and harms in low-fat diets high in processed carbohydrates. So in 2005, US guidelines raised the upper fat limit to 35 per cent and, for the first time, set a lower limit of 20 per cent. Few people noticed, and the low-fat craze continued.

Through continued advances in nutrition science, it is now clear that an emphasis on reducing total fat is not only unhelpful, but can be harmful. Whether for weight loss or preventing long-term weight gain,

“By focusing on total fat, dietary guidelines, policies and formulations have at times become bizarre”

diabetes, cardiovascular disease or cancer, evidence shows that it brings no clear health gain.

In contrast, meaningful health benefits are documented with high plant fat, Mediterranean-style diets supplemented with extra-virgin olive oil or nuts, in which total fat intake makes up more than 40 per cent of calories.

Based on these findings, the US Dietary Guidelines Advisory Committee omitted a total fat limit in recommendations, ahead of final benchmarks this year.

The US, UK and others should take note. Existing advice is driving consumers and industry towards low-fat products high in

by about three-fold in the first three months after leaving.

The population faced huge societal dislocation, and many people died – but the loss of life was down to a natural disaster and our response to a human-made one, not the nuclear accident. So deep is distrust that just one of Japan's 43 reactors has restarted since the shutdown of all its plants.

We should learn from the accident to ensure we don't repeat mistakes. But we must also recognise that an overreaction can produce health risks greater than those of the incident itself.

An inability to keep cool in summer and warm in winter takes a toll on older people, and climate change will affect us all. Societies may have to accept that the health risks of a very rare nuclear power accident are a lot smaller than we allowed ourselves to believe.

If we don't take note of the lessons on risk communication from Fukushima, public mistrust of nuclear power may lead to it being marginalised, despite its potential for powering our future. That would have a much more detrimental effect on the health of future generations. ■

Geraldine Thomas is a professor of molecular pathology at Imperial College London

refined carbs, sugars and salt; and away from healthy higher-fat foods such as nuts, vegetable oils and whole-fat dairy products.

By focusing on total fat, dietary guidelines, policies and food formulations have at times become bizarre and paradoxical. Let's remove this obsolete limit and focus instead on healthy wholefoods and diet patterns. ■

Dariusz Mozaffarian is dean of the Friedman School of Nutrition Science & Policy, Tufts University, Massachusetts; David Ludwig directs the New Balance Foundation Obesity Prevention Center in Boston and is author of forthcoming book *Always Hungry?* (Grand Central)

ONE MINUTE INTERVIEW

Let AI solve your disputes

There's too much talk of Terminators and too little of how artificial intelligence can create fairer societies, says **Ariel Procaccia**



PROFILE

Ariel Procaccia is a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania. He has worked on a variety of "AI fairness" projects, including Spliddit.org

Can AI solve human disagreements?

That's the ideal. In situations where there are disputes or arguments we would want AI to be able to give us intelligent proposals in an automated way. One approach is to base these proposals on principles of economic theory.

How does economic theory help?

The main question here is what is fair. We want a rigorous definition of fairness that the computer can understand. That's where economic theory comes in, because a lot of work has been done on how to formalise, in mathematical terms, what fairness means and then design algorithms that can provably achieve those notions of fairness.

What sort of problems can this tackle?

Maybe the most intuitive example is rent division. Think about a situation where there are a few flatmates renting an apartment together and they have assigned the rooms but now have to divide the rent. The rooms are different – one is larger, one has a nicer view and so on. The algorithm can be informed about the preferences

of each flatmate by getting them to value the rooms and then incorporating their valuations into a final calculation. The outcome we're shooting for is a very compelling property called envy freeness – we don't want anybody to be envious of anybody else.

Is that why you set up a website – to give people the opportunity to try out AI like this?

Yes. In November 2014 we launched Spliddit.org, which helps people fairly divide up goods, rent, bills in restaurants and fares on transport, among other things.

Are you looking beyond these simple scenarios?

With dispute-resolution cases, you can go from simple right up to things like the dispute between the Israelis and the Palestinians. But at all of these levels, I think AI in collaboration with economics could ultimately give pretty good proposals for what outcomes will best satisfy the parties involved. We still have a lot of work to do, however.

So in the future, will AI be making all of our decisions for us?

I think we're far away from the point where AI will completely take over decision-making. The goal right now for this type of application is definitely not to replace human negotiators with robots, negotiating on their behalf, but more along the lines of AI and humans working in tandem.

Some, such as Stephen Hawking, worry that abilities like this could make AI too powerful. Are you afraid?

I knew this question was coming! It's funny, because I just came from a conference on AI in Argentina, where there was a lot of discussion of killer robots. I'm not an expert in robotics or general AI, but the point I do want to make is I think there's too much attention given to killer robots and not enough to the benefits that AI has for society right now. We could talk about those a bit more and Terminators a bit less.

Interview by Chris Baraniuk

STRANGELY FAMILIAR

What if dark matter is normal matter in disguise, ask Sabine Hossenfelder and Naomi Lubick

IT'S matter, but not as we know it. In July, an unexpected visitor appeared at CERN's Large Hadron Collider near Geneva, Switzerland. Dubbed the pentaquark, this peculiar particle represents a fundamentally new way to aggregate the basic building blocks of matter. Although not forbidden by our current understanding of how stuff comes together, it had never been conclusively spotted before.

This sort of thing is music to Glenn Starkman's ears. A theoretical physicist at Case Western Reserve University in Cleveland, Ohio, Starkman is banging the drum for a bold idea: that there are even more exotic configurations of ordinary matter out there just waiting to be discovered. His audacious proposal is to find traces of this oddball matter by various means, from exhuming data left in mothballed gravitational wave detectors and searching ancient minerals to deploying seismometers on the moon. He even argues that ordinary matter in extraordinary formations could

solve one of the greatest cosmological mysteries of our time – dark matter.

For physicists faced with the most difficult conundrums, inventing new particles beyond those we already know has long been the go-to trick. Nobel prizewinner Wolfgang Pauli was an early adopter. In 1930, he proposed that the missing energy in certain experiments was carried off by an elusive particle that escaped measurement. Pauli himself was not happy with his invention. "I have done a terrible thing," he said. "I have postulated a particle that cannot be detected." He needn't have worried: what we now know as the neutrino was found in 1956.

Physicists have been busily inventing particles ever since, and in the process they have built up the standard model – the most complete description yet of particles and their interactions. Its crowning glory came in 2012 with the discovery of the Higgs boson, which explains why particles have mass.

But the standard model doesn't delight physicists. Its mathematical structure appears piecemeal and patched up. And it still contains gaping holes, not least its failure to explain dark matter – the shadowy stuff that accounts for 85 per cent of matter in the universe, yet neither absorbs nor emits light and seems to interact only weakly with other matter.

Faced with this riddle, physicists have followed tradition and contrived dark matter candidates, from weedy WIMPs to massive WIMPZILLAs. But none has been spotted. Contenders suggested by supersymmetry – which predicts that all known particles have a more massive "super-partner" – are also a no-show.

Somewhere along the way, then, the panacea of dreaming up particles has stopped working. That leads Starkman to a provocative conclusion. "Look, the standard model has no experimental failures," he says. "So the fact that we have philosophical and aesthetic



"Exotic clumps of familiar particles could be as dense as neutron stars yet much smaller and harder to spot"

problems with it may be just something we need to get over." Instead of constantly devising particles, Starkman argues that we should look more closely at those we already know. Perhaps old particles are capable of new tricks.

To form the matter that surrounds us, elementary particles come together in certain standard configurations. Quarks combine in threes to form compound particles known as baryons, for instance. The protons and neutrons that make up atomic nuclei are baryons formed of trios of up and down quarks, the lightest two of the six quark variants. We also know of short-lived combinations of a quark and an antiquark, known as mesons.

But quarks are quirky. They never float around freely thanks to a peculiar property of the strong nuclear force that binds them. When the distance between quarks is small, the force is weak. But as that distance increases, it gets stronger and the quarks are pulled back together. Another strange quality of the strong force is that it is weaker at high energies, such as those produced in collisions at the LHC. Physicists can calculate how quarks interact at these energies but not at lower ones, where the force keeping quarks together strengthens. As a result, physicists still struggle to explain how quarks form mesons and baryons, a process which occurs at lower energies.

This uncertainty has led to proposals that other forms of matter might exist. As early as the 1980s, Edward Witten, a mathematical physicist at Princeton University, suggested that light quarks could combine with their heavier cousins, such as strange quarks, in unusual ways (see diagram, right).

Unlike in ordinary matter, these combinations of quarks would not form atomic nuclei. Instead they would develop into large amorphous blobs, gathering ever more particles in a small space. Witten called them "quark nuggets". Bryan Lynn, a theoretical physicist at University College London, and others later expanded this to more examples such as "strange baryon matter" and "chiral liquid drops".

Such exotic clumps of familiar elementary particles would not contain the enormous spaces between atomic nuclei that we see in normal matter. This would make them as dense as neutron stars, a teaspoon of which weighs as much as a mountain. So even though they might be extremely heavy, they could also be tiny. Some researchers have dubbed them "macros" – a reference to the need to measure their masses in kilograms

and tonnes rather than the vanishingly small units usually employed for particles.

And because macros are entirely made up of nuclear matter, without any circulating electrons or empty spaces, they would not be capable of sustaining fusion and therefore could not shine. The high density of the clumps would also make them less likely to interact with incoming light. In short, macros would be diminutive, massive and extremely hard to spot, if not entirely invisible.

Weight watchers

It sounds like the perfect recipe for dark matter. But physicists had previously discounted the idea, for two reasons. First, if macros are compact objects about as heavy as our sun, similar to brown dwarfs or black holes, then they would have to outnumber visible stars in order to account for dark matter. If so, macros would frequently bend the light reaching Earth from stars, an effect known as gravitational lensing. But the amount of bent light we do see is already accounted for by familiar cosmic objects made of normal matter. Second, if nuclear matter were spread out in a thin carpet across the universe, it would interact with itself and other matter, and hinder the formation of galaxies as we know it.

But when Starkman and his colleagues took a closer look, they saw that macros would not have to be so heavy as to cause frequent

gravitational lensing, nor spread out thinly enough to regularly interact with anything. Clumped into medium-sized drops, neither huge nor tiny, they would be compatible with existing cosmological observations.

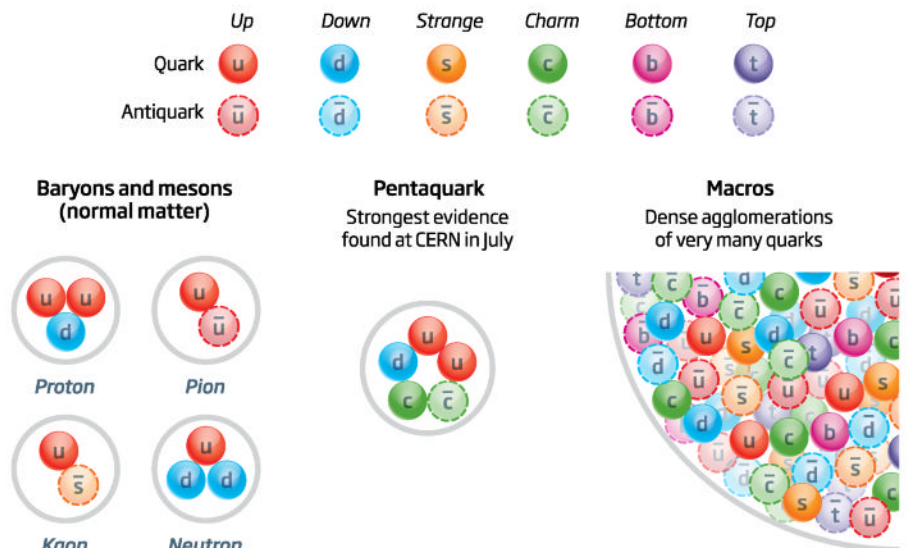
With that in mind, Starkman and his colleagues have begun the search for evidence that such medium-sized macros exist. "This is almost the most silly but definitely the most obvious thing that we should do," says Starkman's collaborator David Jacobs, from the University of Cape Town in South Africa.

They started by trying to figure out where macros at the lighter end of the allowed mass scale might have already showed up. That meant revisiting the work of physicist Paul Buford Price at the University of California, Berkeley, who had searched for signs of massive particles in the Earth's crust back in the 1980s. Price thought that heavy, weakly interacting particles occasionally passing through would have bumped the crystal lattices of transparent minerals known as micas buried deep underground. But his samples, taken from collections held at the British Museum and the Smithsonian Institution, showed no trace of that.

On to plan B. In the 1970s, researchers mounted polycarbonate plastic sheets on the Skylab space station, hoping to spot particles via the etchings they left on the plastic as the craft orbited Earth. Specifically, they were on the lookout for low-energy cosmic ray ions.

Great balls of quarks

In ordinary matter, quarks are bundled in twos and threes. If more could clump together, they could form ultra-massive "macro" particles that could account for the universe's elusive dark matter



Cosmic ray detectors might be tweaked to record oddball matter raining down on Earth



STEVEN SAFFI/PIERRE AUGER OBSERVATORY

Starkman figured that macros too stood a chance of marking the material, but a fresh look at the Skylab plastic did not reveal anything resembling a macro track.

Then there was NAUTILUS, an experiment based near Rome, Italy, that started looking for gravitational waves in the 1990s. NAUTILUS consists of a supercooled 2-tonne aluminium cylinder that is closely monitored for any deformations that could signify the passage of ripples stretching space and time. Starkman, Jacobs and Amanda Weltman, also at Cape Town, figured that a macro travelling through the detector could interact with the aluminium, releasing energy that would cause the device to heat up and deform ever so slightly. Alas, they found no sign of macros (*Physical Review D*, vol 91, p 115023).

The striking absence of signals from these experiments allowed Starkman to further constrain the range of allowed macro masses, but the window of possibilities remains large – between roughly 50 grams and the mass of Mount Everest.

Time to dream up more far-out experiments to narrow the range still further. Jacobs hopes

“If we are right, then this means the LHC won’t see dark matter candidates”

that marine hydrophones, normally employed to study whales or track illegal nuclear weapons tests, may be able to hear the impact vibrations of macros passing through the ocean. He also plans to study data from cosmic ray detectors, designed to look for particle showers created when protons or lightweight nuclei from outer space collide with the upper atmosphere. If a macro interacted with Earth’s atmosphere, it would produce a characteristic light signal, but cosmic ray detectors are not programmed to scan the skies for such hints. Starkman is hoping to persuade the Pierre Auger Observatory in

Argentina to reprogram their detectors.

The best bet might be a little further from home: Earth’s moon. When the last Apollo astronauts departed the moon in 1972, they left behind a network of four seismometers. Over the following five years, these devices recorded thousands of seismic events caused by crashing meteorites, tidal forces or the expansion of the moon’s crust as it warms after a long cold lunar night. Clearly the moon is seismically active, albeit much less so than Earth, with its magma innards and shifting tectonic plates. And it is possible that this quake data could betray macro trails.

In 2002, researchers reported a possible macro signal in Earth’s seismic data, but it turned out to be a false alarm due to an offset clock on a seismometer. Now Starkman and others want to go back to the relative calm of the moon to test the idea that middleweight macros might create a distinctive line of consecutive quakes as they pass through.

The seismometers left on the moon were pretty crude, but planetary geologists are plotting to head back there with better kit. Bruce Banerdt of NASA’s Jet Propulsion Lab in Pasadena, California, and his colleagues have drawn up plans for a more sensitive lunar seismic detection network – and having built one for the InSight mission to Mars, launching next year, he knows what he is doing. “I had no idea just how sensitive a seismometer was until I had to build one,” he says. His Mars instrument is so sensitive that it can pinpoint positions to about the radius of a hydrogen atom – enough to pick up a passing macro.

Is it really worth going to such extremes to hunt for these oddballs from outer space? The difficulty in calculating their behaviour means researchers still can’t be sure that macros could have formed in the necessary amounts to make up dark matter, nor whether they would be stable enough to hold together.

And that’s not the only issue. “I don’t see how it fits into the larger picture,” says Frank Wilczek, a theoretical physicist at the

Massachusetts Institute of Technology. “How do you make this stuff?” He also suggests that if macros exist, they might require less energy to form than ordinary nuclear matter, raising the question of why there is so much ordinary matter around.

Aiming low

What’s more, adds Wilczek, established ideas about dark matter didn’t arise by accident. “I’d be quite disappointed if the dark matter proposals that have evolved logically out of our attempts to improve our theory of fundamentals, and which seem so promising, turn out to be false trails.”

Anne Green, a cosmologist at the University of Nottingham in the UK, is more pragmatic. “Macro dark matter isn’t perhaps as well theoretically motivated as WIMPs, or other particle dark matter candidates, but it’s not implausible,” she says. “It’s certainly extremely worthwhile to look for signs of macros in existing astrophysical and cosmology data sets.”

Their discovery would certainly make a giant splash. For a start, it would mean the colourful cast of exotic particles previously invented and sought by physicists may well not exist. “If we are right, then this means the LHC won’t see dark matter candidates,” says Jacobs.

No one is calling off those searches yet. But rather than reaching for higher and higher energies with particle colliders, perhaps we should seek answers in bringing quarks together at lower energies to better grasp the nature of nuclear matter. Ultimately, this might reveal that the ordinary elementary particles we know and love can come together in some extraordinary ways. The familiar could be about to get very strange indeed. ■

Sabine Hossenfelder is a particle physicist at Nordita, the Nordic Institute for Theoretical Physics, and Naomi Lubick is a freelance science journalist. Both are based in Stockholm, Sweden



ROB HAMMER/AURORA PHOTOS

Circuit train your brain

Whether you need to focus better, improve your memory or curb unwanted cravings, specific exercise regimes can fine-tune your mind.

Teal Burrell reports

PUMPING iron to sculpt your biceps. Yoga poses to stretch and relax. Running to whittle your waistline and get fit fast. There are loads of reasons why it's smart to exercise, and most of us are familiar with the menu of options and how each can shape and benefit your body.

But we are discovering that there are numerous ways in which exercise makes you smart too. Many of its effects have been going unnoticed, but if you were to peer inside the heads of people who like to keep active, you'd see that different exercises strengthen, sculpt and shape the brain in myriad ways.

That the brains of exercisers look different to those of their more sedentary counterparts is, in itself, not new. We have been hearing for years that exercise is medicine for the mind, especially aerobic exercise. Physical fitness has been shown to help with the cognitive

decline associated with dementia, Parkinson's disease and depression, and we know this is at least in part because getting your blood pumping brings more oxygen, growth factors, hormones and nutrients to your brain, leading it – like your muscles, lungs and heart – to grow stronger and more efficient.

But a new chapter is beginning in our understanding of the influence of physical exercise on cognition. Researchers are starting to find more specific effects related to different kinds of exercise.

They are looking beyond the standard recommendation of 30 minutes of moderate, aerobic exercise a day, for the sake of your brain. Are there benefits to going slower or faster? To lifting weights, or performing sun salutations? Whether you want a boost in focus for an exam, find it hard to relax or are keen to quit smoking, there's a prescription for you.

The first clue that exercise affects the brain came from rodent studies 15 years ago, which showed that allowing mice access to a running wheel led to a boost in neuron formation in their hippocampi, areas of the brain essential for memory. That's because exercise causes hippocampal neurons to pump out a protein called brain-derived neurotrophic factor (BDNF), which promotes the growth of new neurons. The mice showed improvements in memory that allowed them to navigate mazes better.

The findings were soon translated to humans. Older adults who did aerobic exercise three times a week for a year also grew larger hippocampi and performed better in memory tests. Those with the highest levels of BDNF in their blood had the biggest increases in this brain region.

The idea that exercise helps to improve memory has been especially welcome given that the search for effective treatments for cognitive decline has been slow in progress. And it now seems that aerobic exercise such as running and cycling may help stave off Alzheimer's disease and other forms of dementia.

As the evidence for aerobic exercise accumulated, Teresa Liu-Ambrose at the University of British Columbia in Vancouver, Canada, began to wonder about other types of exercise. She has been looking for ways to halt dementia in people with mild cognitive impairment (MCI), a population of adults known to be at increased risk of developing dementia, and was especially interested in strength training, which has in recent years been added to US and UK government recommendations for physical activity.

To test the idea, Liu-Ambrose compared the effects of aerobic exercise and strength training in 86 women with MCI. She measured their impact on two abilities known to decline as the condition progresses: memory and executive function – which encompasses complex thought processes, including reasoning, planning, problem-solving and ➤

The ultimate brain workout

Different physical exercises can bring specific mental gains, from improving memory to dealing with cravings or reducing stress

LIFTING WEIGHTS

Prefrontal cortex
complex thinking, reasoning, multitasking, problem-solving

YOGA

Frontal lobe
Insula
integrates thoughts and emotions

Amygdala
fear and anxiety

HIGH-INTENSITY INTERVALS

Hypothalamus
appetite regulation, cravings and addiction

SPORTS DRILLS

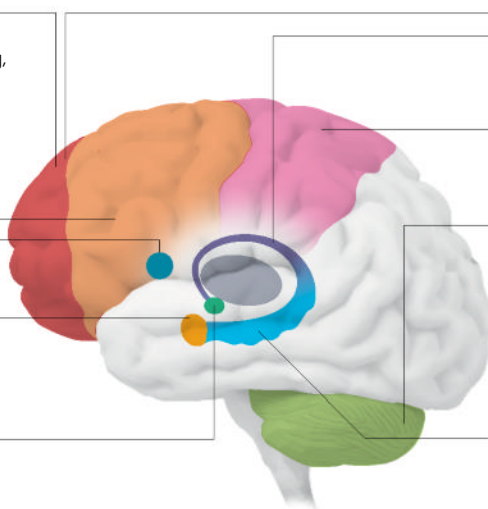
Prefrontal cortex
Basal ganglia
attention, switching between tasks, inhibition

Parietal lobe
visual-spatial processing

Cerebellum
attention

AEROBIC EXERCISE

Hippocampus
memory



multitasking (see diagram, above).

Twice a week for an hour, one group lifted weights, while the other went for brisk walks quick enough that talking required effort. A control group just stretched for an hour instead. After six months of this, both walking and lifting weights had a positive effect on spatial memory – the ability to remember one’s surroundings and sense of place.

On top of that, each exercise had unique benefits. The group that lifted weights saw

significant improvements to executive function. They also performed better in tests of associative memory, which is used for things like linking someone’s name to their face. The aerobic-exercise group saw improvements to verbal memory – the ability to remember that word you had on the tip of your tongue. Simply stretching had no effect on either memory or executive function.

If aerobic exercise and strength training have distinct benefits, is combining them the

way to go? To address this, Willem Bossers of the University of Groningen in the Netherlands split 109 people with dementia into three groups. One group walked briskly four times a week for 30 minutes; a combination group walked twice a week and strength-trained twice a week for 30 minutes each; and a control group did no exercise. After nine weeks, Bossers put the participants through a battery of executive-function tests that measured problem-solving, inhibition and processing speed. He found that the combination group showed more improvement in executive function than the aerobic-only or control groups. “It seems that, for older adults, walking only is not enough. They need to do some strength training,” he says.

Immediate attention boost

And these benefits extend to healthy adults too. In a year-long trial of healthy older women, Liu-Ambrose found that lifting weights, even just once a week, resulted in significant improvements in tests of executive function. Balancing and toning exercises, on the other hand, did not.

The combination of lifting weights and aerobic exercise might be particularly powerful because strength training triggers the release of a molecule called insulin-like growth factor-1 (IGF-1), a growth hormone produced in the liver that is known to affect communication between brain cells, and to promote the growth of new neurons and blood vessels. On the other hand, aerobic exercise mainly boosts BDNF, says Liu-Ambrose. In addition, Bossers says strength training also decreases levels of homocysteine, an inflammatory molecule that is increased in the brains of older adults with dementia. By combining aerobic exercise with strength training, you’re getting a more potent neurobiological cocktail. “You’re attacking the system in two ways,” he says.

The studies so far haven’t addressed how long the effects last, but preliminary findings suggest adults will have to keep exercising to maintain the benefits.

Another approach is to start young, with findings that different types of exercise affect a child’s mental capacity in a number of ways. For example, if you want kids to focus for an hour – on a maths test, say – the best bet is to let them have a quick run around first. That’s according to studies that show a simple 20-minute walk has immediate effects on children’s attention, executive function and



FEELING ANXIOUS? SAY “OM”

After a running injury, Sara Lazar decided to try yoga. She initially rolled her eyes when the instructor touted the mental-health benefits, but after a while she realised she felt better able to handle difficult situations. She decided to look into it at her lab at Massachusetts General Hospital, recruiting people who were experiencing high levels of stress to attend yoga and meditation classes for eight weeks. They also practised at home for 20 minutes a day. By the end, brain scans showed the volunteers’ amygdalae – brain regions that process fear and anxiety – had shrunk, and participants reported feeling less stressed. While it’s not yet clear why, yoga’s meditative aspect helps develop a calmer outlook, which in turn reduces fear and anxiety, says Lazar.

"Lifting weights helps improve complex thoughts, problem-solving and multitasking"



BRUNO BARBEV/NAGAMATSU PHOTOS

achievement in mathematics and reading tests. Letting kids sprint or skip about has the same effect. A brisk walk can also help children with attention-deficit hyperactivity disorder to focus, although again it's not yet clear how long the effects last.

These findings should be used to make decisions about the daily school routine, says Charles Hillman at the University of Illinois at Urbana-Champaign, who carried out some of the research. He agrees with current recommendations that children get at least an hour of exercise daily, but notes that it might be best spread over the course of the day. Because purely aerobic exercise keeps kids focused in the near term, giving them breaks to walk or move around every 2 hours might be the best way to promote learning.

In contrast, exercise that is highly structured and focused on specific skills, such as for a sport or to improve coordination, hampers attention. A bunch of drills and rules may be too taxing for children right before a test or a situation that requires sustained focus.

Instead, these kinds of specific exercises seem to build up attention span gradually over the long-term. In research yet to be published,

Mind over matter:
improving attention
can help mobility.
The stick is optional

Maria Chiara Gallotta at the University of Rome in Italy found that twice-weekly sessions of coordinative exercises, such as basketball, volleyball or gymnastics practice, over the course of five months helped children do better on tests that required concentration and ignoring distractions.

The cerebellum – the finely wrinkled structure at the base of the brain – has been long known to be involved in coordinating movement, but is now recognised as having a role in attention as well. Practising complicated movements activates the cerebellum and, by working together with the frontal lobe, might improve attention in the process.

MIND GAMES FOR MOBILITY

Moving the body can tone the mind (see main story), but could the reverse also be true?

In other words, says Lindsay Nagamatsu at the University of Illinois at Urbana-Champaign, can a mental workout influence how the body moves?

It is commonly assumed that everyday movements like walking and maintaining posture are automatic. But even if we don't consciously think about them, they still require a level of attention.

This becomes more apparent as we age, and Nagamatsu's earlier work shows that older people whose minds tend to wander, or who score poorly on attention tests, are more likely to take a fall. Physiotherapy and exercise improve mobility, but Nagamatsu wondered if a boost in attention span could too.

To test this, she used a computer game that is known to improve attention and perception called Music Catch. She got people aged between 60 and 80 to either play this game for a total of 15 hours over five weeks, or another game known to help with working memory and reasoning but not attention.

Before and after this she tested their walking speeds, a commonly used indicator of someone's risk of falling or being able to live independently.

Nagamatsu showed that the Music Catch group ended up with significant improvements in speed. The game seemed to be particularly helpful because it required paying attention to multiple things at once, as we do when walking while carrying on a conversation, for example.

And walking speed might be important more generally: "It has also been shown to predict morbidity and mortality in older adults," says Nagamatsu, "so I think that it's an important outcome to try to improve."

Making sure children are physically fit can have lasting cognitive benefits too, says Hillman. He has shown that children who are fit have larger hippocampi and basal ganglia, and that they perform better in attention tests. The basal ganglia are a group of structures important for movement and goal-directed behaviour – turning thoughts into actions. They interact with the prefrontal cortex to influence attention, inhibition and executive control, helping people to switch between two tasks, such as going from sorting cards by colour to sorting cards by suit.

Hillman focuses on children aged 8 to 11 because areas like the hippocampi and basal ganglia are still maturing, so intervening at ➤

a young age can make a big difference. And even small gains in fitness lead to measurable changes in the brain. In some of his studies, Hillman has put kids on year-long after-school fitness programmes. Many are overweight, and while they don't lose much weight, their brains do change. They're going from being unfit to slightly less unfit, says Hillman. "But we're still finding benefits to brain function and cognition."

Adults too can reap brain gains from sporty challenges, says Claudia Voelcker-Rehage at Chemnitz University of Technology in Germany. Her research on older adults showed an increase in basal ganglia volume following coordination exercises that included balancing, synchronising arm and leg movements, and manipulating props like ropes and balls, but not from aerobic exercise.

Surf yourself smart

So why the added benefits? Such activities require an understanding of where things are in space, so one explanation is that they activate both the visual system and the parietal lobe, the part of the brain that integrates sensory and spatial information.

Indeed, Voelcker-Rehage found that these types of exercise improved visual-spatial processing, required for mentally approximating distances – for instance, being able to assess whether you have time to cross the street before an oncoming car reaches you – more than aerobic exercise.

Another explanation comes from recent research by Tracy and Ross Alloway, both at the University of North Florida in Jacksonville. They found that just a couple of hours of activity of the type we often enjoy during childhood, such as climbing trees, crawling along a beam, or running barefoot, had a dramatic effect on working memory.

This is the ability to hold on to information and manipulate it in our minds at the same time. "It prioritises and processes information, allowing us to ignore what is irrelevant and work with what is important," says Tracy Alloway. "Working memory influences nearly everything that you do, from the classroom to the boardroom."

So what is it about climbing trees or beam balancing that is so beneficial? The researchers only found positive results when the activities were a combination of two things. They needed to challenge the sense of proprioception – the position and orientation of the body – and also needed at least one other element, such as navigation, calculation

LET LOOSE FOR CREATIVITY

Daniel Schwartz practises what he preaches. During our interview he is strolling through Stanford University's leafy campus, an activity that according to his research boosts divergent creativity – otherwise known as thinking outside the box.

It is walking at a leisurely, everyday pace that does this, not at a speed that would be aerobically challenging or make you out of breath. In Schwartz's study – which he thought of while out on a walk – people came up with more unique uses for everyday objects when walking outside or on a treadmill than when seated. He even found that taking a walk has a stronger effect on creativity than IQ. And people continued to be more creative afterwards, suggesting a saunter before a brainstorming session is a good idea.

Or, if you're more of a jitterbug, Peter Lovatt, a dance psychologist at the University of Hertfordshire, UK, suggests you "put on some music and start having a boogie", and the key is to keep it loose. After a session when people had to improvise dance moves, they came up with more creative answers to problems than after a structured dance session or no dancing at all. It seems that creative movements – no matter how silly – lead to creative problem-solving. In fact, the sillier the better: the trick is to move in different ways. So if you tend to move your arms a lot when you dance, focus on your hips instead. "Having a spontaneous wiggle – without any pre-planning – is really good for divergent thinking," Lovatt says.



Taking a stroll can get the creative juices flowing

"Chocolate lovers consumed half as much after a brisk 15-minute walk. For smokers, 10 minutes of biking reduced cravings"

or locomotion. Basically, the advantages came from exercises in which we need to balance and think at the same time.

A good example is surfing, says Alloway. "In order to even catch a wave, you have to pay so much attention to proprioceptive information or you slip off your board; you also have to judge the best position to be in order to catch it, as well as to determine if another surfer has priority to catch a wave." In their study, a group who did yoga, which involves proprioception, but not much mental reasoning, didn't see improvements in working memory; nor did a group merely

learning new information in a lecture setting.

The results were the same for children and adults. "The adults in our study showed improved working memory after just a couple of hours of doing playground-type activities," Alloway says.

The more we learn about the effects of exercise on the brain, the more different types of benefits are emerging, extending beyond cognition to changes in behaviour.

One of the most popular fitness trends of the last few years is high-intensity interval training, which involves quick spurts of all-out exercise. Its sheer toughness is claimed to



MARTIN PARR/MAGNUM PHOTOS

occasions. On three of the visits, they spent 30 minutes on an exercise bike, but at different intensities – a moderate, continuous pace; alternating between intervals of high-intensity cycling for 1 minute followed by 4 minutes of moderate cycling; or alternating between very high intensity, 15-second sprints followed by one really easy minute. The fourth visit consisted of resting for the full 30 minutes.

Craving control

After the most intense intervals, the men ate less of the provided, post-workout porridge and less food overall for the next day and a half compared with days they cycled moderately or simply rested.

One explanation could be that the exercise reduced levels of the “hunger hormone”, ghrelin. This is responsible for telling the part of the brain that controls eating – the hypothalamus – when the stomach is empty. When full, ghrelin production shuts off and hunger wanes. Following the most intense intervals of exercise, ghrelin levels were lowest.

If intensity isn’t your thing, you could also play with the thermostat. Guelfi and others have shown that exercising in the heat reduces appetite, while exercising in the cold increases it. Again, hormones like ghrelin or a small protein called peptide YY could well be at play.

And although vigorous activity might curb appetite and stall cravings for longer, even moderate exercise can help. Adrian Taylor, now at Plymouth University in the UK, has found that short bouts of activity can reduce cravings for both sugary snacks and cigarettes.

In earlier work, Taylor found that chocolate lovers consumed almost half as much of it after a brisk 15-minute walk as those that rested quietly. For smokers, 10 minutes of

moderate biking helped reduce self-reported cravings. Smokers’ brains were also scanned while they viewed images designed to trigger cravings. Following cycling – despite staring at pictures of cigarettes after being deprived for 15 hours – the smokers’ brains appeared relaxed. Regions implicated in addiction were less activated after exercise, as if the tempting cigarette were no more meaningful than a pencil.

It’s conceivable that exercise merely distracts from the urge, but studies show that cravings were reduced more following a short bike ride than after another distracting task involving mental arithmetic.

It’s still early days, and while some of the studies point at possible mechanisms behind the benefits, other effects have yet to be explored. One theory is that certain types of exercise increase blood-vessel formation in the brain, and so keep it working well. Exercises that activate specific regions may bring more blood to those areas, possibly building new vasculature that improves its functioning, whether it be for better memory or better problem-solving. And doing something unfamiliar, like learning a dance step or balancing on a beam, could also create novel connections between neurons, Voelcker-Rehage suggests.

What is clear is that these effects can endure well into old age, and it’s never too late to start. The hippocampus shrinks as we get older, leading to the typical struggles with memory. But aerobic exercise not only prevents this loss – it reverses it, slowing the effects of getting older. Voelcker-Rehage has found that the brain requires less energy to complete certain tasks after exercise. “We would say that points to the fact that the brain is more efficient,” she says. “It works more like a young brain.”

And in a study looking at yogis that had been practising for many years, Sara Lazar at Massachusetts General Hospital found that some brain regions were remarkably well preserved compared with those of healthy controls that were matched for age, gender, education and race. “The 50-year-old’s brain looked like a 25-year-old’s,” notes Lazar.

If you’re still unsure which type of exercise to pick, there’s some overlap between the different exercises and benefits, so Liu-Ambrose’s suggestion is simple: “If you’re not active, do something that you enjoy.” The best exercise is the kind that you’ll actually do. ■

Teal Burrell is a science writer based in Washington DC. Links to studies appear in the online version of this article at bit.ly/NSbraintrain

provide the same benefits as longer efforts in a fraction of the time.

These workouts might have an extra advantage: short bursts of activity can help curb cravings. And although the tougher the better, they don’t necessarily have to be gut-bustingly hard.

To test the effects of intensity training on appetites, Kym Guelfi at the University of Western Australia in Perth invited overweight men to come into the lab on four separate

EIGHT WAYS EXERCISE CAN BOOST YOUR BRAIN

IMPROVE WORKING MEMORY – surfing, running, climbing trees

BOOST CREATIVITY – dance or stroll

DE-STRESS – yoga

IMMEDIATE ATTENTION – unstructured play

LONG-TERM FOCUS – play sports

KEEP THE BRAIN YOUNG – running, yoga

CURB CRAVINGS – interval sprints

PROBLEM-SOLVING – lifting weights



XAVIER ZIMBARDO/GETTY

GET LUCKY

Microwave ovens, penicillin, Post-it notes, Viagra: the history of invention is full of chance finds. But can serendipity be learned, asks **Bob Holmes**

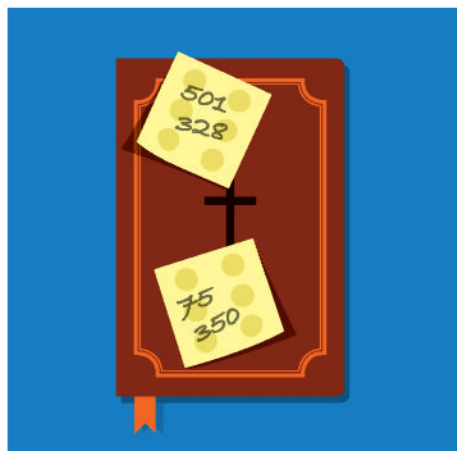
IF YOU want to make petunias a deeper purple, you could just add an extra pigment gene, right? Wrong: the extra gene turns the flowers white. This surprising finding was made independently in the early 1990s by two plant biologists, Richard Jorgensen in the US and Joseph Mol in the Netherlands. Neither dismissed the finding as an error. They suspected they'd found something big, and they had: an entirely new way in which cells regulate gene expression, now called RNA interference. RNAi has since been the subject of a Nobel prize, has saved lives and promises to save many more.

This is by no means the only example of good luck in science. Percy Spencer, an engineer at the US company Raytheon, was working on a radar set in 1945 when he noticed that a candy bar in his pocket was melting. That observation led, two years later, to Raytheon introducing the first commercial microwave oven. In 1976, chemist Shashikant Phadnis's boss asked him to test a chlorinated sugar compound being studied as a potential insecticide. Phadnis misheard it as a request to "taste" the stuff – a scary mistake to make in his line of work – and found it was extremely sweet. We now know it as the sweetener Sucralose. Viagra was a drug proving not so effective for heart conditions before someone noticed an interesting and highly marketable side effect.

Examples like these show that chance plays a role, sometimes a dramatic one, in the progress of science. Yet how much do we really know about its contribution? Its influence would be easier to gauge if we could pin down how it shows up: is it like buying a winning lottery ticket – something that can happen to anyone – or was Louis Pasteur right to say that "chance favours only the prepared mind"? At

least one academic thinks not only that Pasteur was correct, but that it is possible to train minds to be receptive to the subtle signs of chance. This September he will launch a course to do just that.

Opinions differ widely as to how frequent a part chance plays in science. "There are not so many stories about serendipity. Basically, you have a couple of dozen, but in the scientific literature over the last 200 years there are so many discoveries from just plain hard work," says Jacob Goldenberg, an innovation researcher at the Arison School of Business in Herzliya, Israel. "If you tried to assess the ratio between serendipity-based discovery and not, I would say less than half a per cent were the result of serendipity. But we like these stories."



PATRICK GEORGE



LUCKY FIND

Inspired by the burrs that stuck to his trousers after hiking, the inventor **George de Mestral** went on to develop **Velcro**.

school, an office mate who happens to know a useful tidbit of information, an experiment that improbably works out well. All of this involves chance; but it doesn't necessarily mean discoveries happen by chance.

One of the hottest areas of neurobiology, for example, is optogenetics, which allows researchers to control the behaviour of groups of neurons with great precision. While at Stanford University in California, Ed Boyden discovered a key technique in the field, the use of light-sensitive proteins from algae to trigger electrical activity in neurons. He and his co-workers (already like-minded – the first stroke of luck) had been thinking for years about using light to control neurons. Then they stumbled across the algal studies (more good luck) and decided to try inserting the genes responsible into mouse cells.

"It kinda worked on the first try," recalls Boyden, now at the Massachusetts Institute of Technology Media Lab. "Who would have known that these molecules from algae, which are very different organisms, would work in neurons? That was also serendipitous." As they later learned, they were even luckier than they knew: the algal protein requires another molecule to work properly, and mammalian brains just happen to produce it for an unrelated reason.

Even so, serendipity was only half the story. Controlling neurons is an idea Boyden and his colleagues were keen on; in Pasteur's parlance, their minds were "prepared".

Perhaps the most iconic example of chance in science is Alexander Fleming's discovery of penicillin. In 1928, a stray fungal spore landed in a discarded bacterial culture in his lab at St Mary's Hospital, London. When Fleming looked at it weeks later, he saw a ring around ➤

LUCKY FIND

The 19th-century chemist **William Perkin** was trying to synthesise the colourless antimalarial drug quinine from coal tar. He ended up with a vivid purple compound: the world's first **synthetic organic dye**.

Others think chance's role is more significant. "Every decent idea I've ever had, I had no idea about until I started doing the research and it didn't turn out the way I expected," says Harry Collins, a sociologist of science at Cardiff University, UK. If we underestimate the good-luck factor, it could be to do with scale. "I would think little surprises are there often, and big surprises are rarer," says Michael Gorman, a social psychologist at the University of Virginia in Charlottesville.

One reason for the divergent views is the difficulty in defining chance. All of life, after all, is a walk down branching paths, and the direction at each fork often hangs on chance events: having an inspiring science teacher in

LUCKY FIND

Roy Plunkett, a chemist for DuPont, was working on a new chlorofluorocarbon refrigerant when he noticed that it left a slippery coating on its container. It now goes by the name of **Teflon**.

the growing fungal colony where something had killed the bacteria nearby. That something was eventually identified as penicillin.

Yet Fleming's finding did not pop out of a vacuum. Other scientists over the preceding century, including Pasteur, had noticed that moulds inhibit bacterial growth. Fleming himself had spent years looking for bacteria-killing compounds and had already found one – lysozyme, an enzyme he isolated from the snot of a person with a cold. Fleming's prepared mind connected the dots, but even so, it was another decade before other researchers, Howard Florey and Ernst Chain, figured out how to turn the mould into a drug.

Discoveries like these are often called “pseudo-serendipity” – the scientists knew what they were looking for but found the answer in an unexpected place. The writer Arthur Koestler vividly described such finds as “arrivals at the right destination by the wrong boat”. Taken to extremes, this approach can pretty much remove the element of chance from discovery. The inventor Thomas Edison, for example, tested hundreds of materials before he found the right filament for his electric light bulb, and pharmaceutical companies now systematically screen hundreds of thousands of substances looking for new drugs. When such an “Edisonian materials dragnet”, as Gorman puts it, turns up something useful, that's a testament to hard work more than luck, he says.

In contrast, true serendipity happens when researchers stumble across something entirely unexpected, as in the discovery of microwave heating or Sucralose. Here luck plays a much more obvious role – although every case still needs an alert observer to notice the anomaly, not discount it as an error and turn it into a useful result.

A starting point for having a good idea is to list all possible ones

Some examples, though, fall in between. Take the case of the scientist at the chemicals giant 3M who was trying to create a super-strong adhesive but ended up with a super-weak one. Years later, a colleague decided it was just the thing to stop place markers falling out of his hymn book in church. That inspiration spawned Post-it notes.

This sort of accident turns out to be fairly common in the annals of innovation. When Goldenberg studied the origin of

200 important inventions, he found that in about half of the cases, the old saying had it backwards: invention was the mother of necessity. “First they found the invention, then they discovered the need,” he says. That makes the final product not exactly an accidental discovery. It's more a matter of finding the best way to play the hand you've been dealt.

“It's much easier to find a function for an existing form than the other way around,” says Goldenberg. “People are very creative when you have a form.” He points to the example of Vaseline, which has its roots in a dark sludge left over from oil processing. Only when chemists began looking for an application did they discover they could use the purified jelly to help burns heal.

Luck clearly helps some technologies bloom, but its impact on the broader world of scientific discovery is unclear. No one seems to have made a systematic survey of scientific breakthroughs to measure how often chance plays a large part.

Indeed, such a survey may be almost impossible to do properly, says Dean Keith Simonton, a psychologist at the University of California, Davis, who studies creativity. Scientific papers may not mention what inspired their findings. Besides, chance may be inextricably intertwined with hard work,



making it difficult to weigh the relative contribution of each. “Even if we accept Newton’s falling apple experience as valid, how much of his *Principia* should be credited to serendipity?” he asks.

Perhaps the most direct attempt to quantify scientific serendipity came two decades ago, when Juan Miguel Campanario of the University of Alcala, Spain, surveyed 205 of the most highly cited scientific papers of the 20th century and found that 17 of them, or 8.3 per cent, mentioned some kind of serendipity contributing to the findings. This probably underestimates the true frequency, however, seeing as not every author is likely to mention their good fortune in print.

Even if there’s little certainty about how common serendipity is in science, there is broad agreement that more of it is a good thing – if only because it leads to more original discoveries. “If you’re working on something where all you have to do is be smart and work hard, chances are somebody’s already found it,” says Boyden. “So we’re often trying to do things to deliberately encourage serendipity.”

Boyden has made something of a cottage industry out of wooing Lady Luck. This autumn he plans to teach a course at MIT on nurturing serendipity, in which he will ask each group of students to systematically set out to revolutionise one area of science. “I think we’ve learned enough now about how to orchestrate serendipity that maybe we should teach it,” he says.

Boyden’s first rule for making your own luck in research: list all possible ideas to pursue. That’s not as silly as it sounds, he argues. The trick is to subdivide the universe of possibilities into either/or options, and do it over and over again. If you’re looking for a

LUCKY FIND

In the 1930s, **Karl Jansky**, an engineer at Bell Labs, was investigating noise in transatlantic radio transmissions when he discovered that the static came from a fixed direction in the sky. This observation founded the field of **radio astronomy**.



novel way to image the brain optically, for example, you could either detect photons within the brain or wait for them to leave the brain and detect them outside. If you’re doing it within the brain, you could use either active electronics or a passive detector. And so on. He calls this approach a “tiling tree” because it branches like a tree and covers the entire “idea space” like tiles on a floor.

Blue sky’s the limit

In effect, it’s an Edisonian dragnet for ideas. “You can subdivide into smaller and smaller categories, but you never lose any possible ideas. At the very ends of these branches are things you could try out.” That step is where serendipity might appear.

Boyden’s second tip is to range widely. His own research group includes engineers, physicists, neuroscientists, chemists, mathematicians and more. This diversity increases the odds that someone will make an unexpected conceptual connection. In the same vein, it’s good to work on more than one thing at once, as this also boosts the likelihood of cross-pollination. This was a key source of Thomas Edison’s creativity, for example. In a study of the chronology of all 1093 of Edison’s patents, Simonton found that the more subjects he was working on, the higher his output of patents.

A more controversial way to encourage serendipity, especially discoveries that open whole new fields of science, is simply to find the smartest, most creative thinkers and give them unrestricted funding to get on with it.

That’s what used to happen at legendary research centres like Bell Labs, and still happens to some extent at Google, for example, which allows its engineers to spend

LUCKY FIND

Barnett Rosenberg was studying the effect of electricity on bacteria in the 1960s when he noticed that some of the cells had lost the ability to divide. The culprit was a by-product from a platinum electrode. We now know it as **cisplatin**, one of the most effective anticancer drugs.

20 per cent of their time on side projects. Back in the 1980s, oil giant BP also funded a blue-skies research initiative with the goal of seeking out the very best scientists and funding them with no strings attached. “I had 13 years of freedom at BP,” recalls Don Braben, who ran the programme and is now at University College London. “We had 10,000 applicants and I picked just 37,” he says. “Fourteen of those won major breakthroughs.”

That’s a lesson funding agencies still need to heed, says Collins. “It’s difficult to have a policy to encourage serendipity,” he says. “But it’s not difficult to have a policy to discourage it.” Winning research grants is now so competitive – with just 10 per cent of applicants getting funded in many cases – that researchers have to play it safe and go after results they know they can achieve, he says. More adventurous proposals, those that might stumble across something altogether new, tend to be too risky to gain funding.

In essence, today’s system is a self-fulfilling prophecy: it doesn’t believe in chance and so chance discoveries seldom happen. Yet, with some enlightened thought – and a little bit of luck – that could be reversed. ■

Bob Holmes is a consultant for *New Scientist* based in Edmonton, Canada

MORE CHANCE ENCOUNTERS

Is the era of serendipity over? Read in next week’s issue how human ingenuity is increasingly being supplanted by machines – and how computers are even taking over our mathematical journey of discovery. Copies of *New Scientist*’s latest book on Chance, out on 5 November, are available to pre-order at bit.ly/ChanceBook

Ghosted in the fug of chronoslip

You can lose your self in games, and even your life, finds **Douglas Heaven**

Death by Video Game: Tales of obsession from the virtual frontline
by Simon Parkin, Serpent's Tail, £12.99



WE START with a body. In February 2012, a member of staff at the Big Net internet cafe in New Taipei City, Taiwan, realises that the young man slumped in front of a screen is not asleep.

Chen Rong-yu had been dead for nine hours. His arms were still in front of him, hands flexed into the shapes they had held over keyboard and mouse. "Like the pulp detective thriller in which the lifeless hand points towards some crucial clue, Rong-yu's final pose appeared to incriminate his killer," writes Simon Parkin.

But *Death by Video Game* is not a whodunnit. Sure, there are several unexplained deaths, some red herrings, and a host of usual suspects. But for the hundreds of millions of gamers worldwide who don't wind up dead, there is a more important question. The book is a whydunnit, says Parkin.

Rong-yu's case sounds extreme. He had been playing *League of Legends*, an online team-battle game, on and off for 23 hours before resting his head for the last time. He is one of a handful of people who have died playing a video game since *Space Invaders* conquered the world in the 1980s. Why do video games inspire such monumental acts of obsession? Other pastimes can be equally absorbing. Yet we don't hear of death by novel, or death by film.

"Any activity that compels a human being to sit for hours on end without moving is, arguably, a mortal danger," writes Parkin. You could die sprawled on the sofa in a box-set binge, or reading *Harry Potter*. But you don't. Video games, he argues, are different.

Already in Taiwan police are doing spot checks in cafes after 10pm to see if any under-18s are still there. The Taiwanese government is bringing in regulations on how long teens are allowed to play. Films have long had age ratings, but video games may end up being the

"We don't allow customers to play for more than three days at a time, says one manager of a games cafe"

first entertainment medium in history to attract legislation controlling how long anyone can interact with them before taking a break, writes Parkin.

Cafe owners are also taking measures: dead customers are bad for business. "We have a

system to prevent customers from sitting in front of the computer for too long," says the manager of the Ingame Café in Tainan, not far from where Rong-yu died. They will now ask customers to leave. "We don't allow any customers to play for more than three days at a time."

Fears about the dangers of time-wasting activities are perennial, of course. Parkin cites a *Scientific American* article from 1859 about the dangers of chess: "Those who are engaged in mental pursuits should avoid a chessboard as they would an adder's nest, because chess misdirects and exhausts their intellectual energies."

But for Parkin, one of the best writers around on games and games culture, the effects are way beyond moral panic. As he describes it: "We consume a book, but a game consumes us. It leaves us reeling and bewildered, hungry and ghosted in the fug of chronoslip."

Games take us out of ourselves to such an extent that we forget where we are. We lose the sense of time passing. We swap our normal lives for the power fantasy, the exotic, the elsewhere. "When Rong-yu's heart failed, he simultaneously departed two realities," observes Parkin. He died in a corner of an internet cafe. And he died in a game.

Rong-yu may have had a pre-existing heart condition, he may have suffered from deep vein thrombosis, he may have collapsed because of the poor quality of air inside the cafe. Or he may have been killed by a cycle

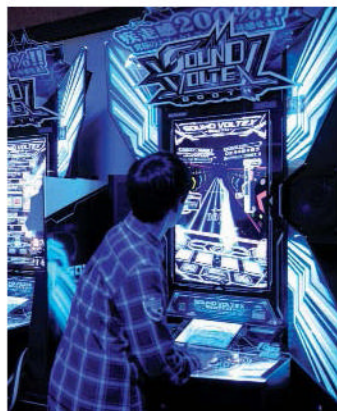


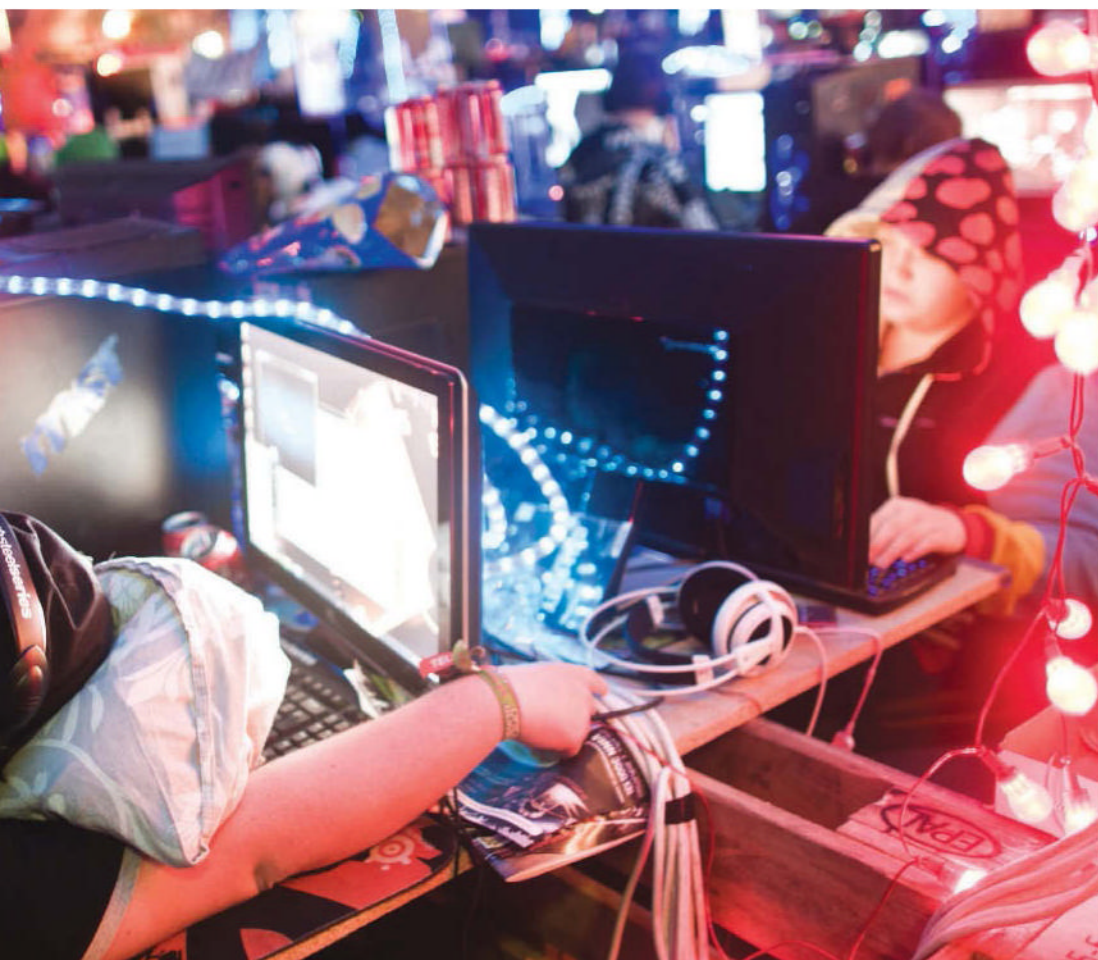
BOTTOM LEFT: DAVID LEFRANC; CORBIS MAN; JAN JOHANNESSEN / PANOS

of stress and release over a long period of time that elevated his blood pressure and heart rate. Many play games with the focus and enthusiasm of an employee chasing a promotion. The Japanese have a term for that: *karoshi*, death by overwork.

But Parkin's quest for the big picture quickly takes him on to the many ways in which video games are a part of life. This is a book about people, not games. We meet the arcade performers and the e-sports athletes. We meet the players who want to be better than everyone else and the players who simply want to fit in. We meet those seeking refuge and those looking for escape.

We have loved games since the beginning. In the 1970s, *Pong* arcade machines proved so popular that their coin





The exciting potential of the video game fizzles on the restless screen

he says. They let you have fun with friends, yet stay safe at home.

Far from being loners, players make friends globally through games. “The social connections that they encourage, both within Iraq and beyond, have built empathy in ways that may have a profound effect on the way some young people view their place in the world,” explains Parkin.

But the world view reflected in big-name games remains one-sided. Games spread a particular set of Western values. What previous generations picked up from *Rambo*, today’s kids learn via shooters like *Call of Duty* or *Battlefield*.

For a very different form of engagement, Parkin introduces us to Ryan Green. When Green’s infant son was diagnosed with cancer, he decided to make a game about it. In *That Dragon, Cancer*, players experience what it is like to try to console a 4-year-old in pain – and fail. Baby Joel cries and there’s nothing you can do but pray. For Green, games are a way to invite people in. “I want people to love my son the way I love my son, and to love my son you have to meet my son,” Green tells Parkin.

Joel died last year. His father is still making the game, now a celebration of a life as much as a study in human suffering.

As a teenager, Parkin’s parents separated. Games gave him routine and direction when he needed it. “Literature is able to remove us from our own lives and focus on the hopes, dreams and conflicts of another,” he writes. “But only a video game gives us the sense of being in control, of being the author of our destiny.”

Video games won’t save you, says Parkin. They might even kill you. But, as he writes, “the potential – that shimmering, vivid, endlessly exciting potential – is there, fizzing on the restless screen.” For good or ill, that potential is our potential too. ■

mechanisms seized up. But we’ve come a long way in four decades. Now there are games for anyone, about anything: they reflect the human condition even more than novels or films, Parkin argues. Here lies their power, their compulsion.

Parkin takes us out in London on a Saturday night. In a games arcade just off Piccadilly Circus, a crowd loiters around a machine with big speakers and a small platform. “They are not here to play,” he writes. “They are here to perform.” *Dance Dance Revolution* is an excuse for a dance-off – part *West Side Story*, part hopscotch. When the music starts, coloured markers flash in time, showing where you need to place your feet. The adept are worth watching, and know it.

Public performance is now a big

aspect of video games, in arcades and now online via YouTube and Twitch. “Video games are closer to music than film in this regard,” writes Parkin. “They allow their players to accent, to flex, to showboat, to be virtuoso.”

And the “rush” generated by competition, by chasing high scores, is also a big part of the obsession. Like sports, games are challenging, driving players to strive for domination. They are an opportunity to measure yourself against others, and an outlet for aggression and rivalry.

League of Legends, the game Rong-yu played, is one of several games to become a sport. Teams compete for million-dollar prizes in international tournaments. But you don’t have to be a pro to be gripped by the urge to win. “For some people, devotion to

improving at a video game begins to mimic the unbreakable grip of substance addiction, if not the chemical dependence.”

Parkin takes us to Baghdad, where military-themed shooters, with players taking on the role of a soldier to blast through their

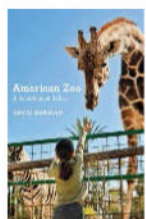
“A video game gives us the sense of being in control, of being the author of our destiny”

enemies, are particularly popular with the generation who grew up during the Iraq wars. Mohammad Abdulla, a 25-year-old Iraqi, was taught how to use an AK-47 at school. “Shooting terrorists in a game is cathartic,” Abdulla tells Parkin. There is also little else to do. “Video games are the only viable entertainment we have,”

Peering through the bars

The 21st-century zoo is an infuriating, conflicted place. It is also amazing, says **Matthew Cobb**

American Zoo: A sociological safari
by David Grazian, Princeton University
Press, \$29.95/£19.95



LIFE changes when you become a parent. For David Grazian, a cultural sociologist and urban ethnographer, it

led to a major shift in his research. He had studied nightlife in Chicago and Philadelphia, but after the birth of his son, Scott, he found himself repeatedly visiting local zoos. It was there that he got the idea for this book, which he calls “a sociological safari”.

Grazian became a volunteer helper, or docent, at some of these places. As well as being bitten, and defecated, urinated and puked on by various animals, he thought hard about the way that zoos are constructed and how the public interacts with the animals and exhibits. He and his son also visited 26 other zoos and aquariums around the US.

In *American Zoo*, Grazian deconstructs the modern zoo. Although he is critical of the anthropomorphisation of its animals, his experience enables him to realise that it can help with teaching. When he shows giant hissing cockroaches to the public, calling one of them Charlie helps to overcome the fears of both parents and children.

Some of the surprising stories in the book may reflect differences between US and European zoos. I am not sure that in the UK it would be keepers,

rather than a vet, who would kill sick animals, or cut the head off a recently deceased jaguar for a post-mortem, as Grazian describes, but I may be naive. National differences aside, the same contradictions prevail between commercial, scientific, educational and entertainment considerations.

Grazian explores what happens when zoo managements follow the money rather than their mission, such as collaborating with US TV shows like *Ghost Hunters*. He describes from the inside how a zoo can quickly degenerate into a “circus environment” if management makes the wrong choices. London Zoo’s recent experience with late-night drunken revellers – described in Grazian’s book – shows that such situations exist on both sides of the Atlantic.

He also invites the reader to consider how animals are presented to us and the way

“exotic” cultural symbols are added to give local flavour to enclosures – coloured Tibetan prayer flags adorning a snow leopard pavilion in San Francisco, and warning signs in Cyrillic script at the Bronx Zoo’s Siberian tiger exhibit are two very mild cases.

It is a lazy graphic vocabulary that zoo architects are too quick

“I am not sure that in the UK keepers would kill sick animals, or cut the head off a recently dead jaguar”

to employ and we are too idle to challenge. The zoos, their visitors, and above all the animals, deserve better. After reading Grazian’s book, next time you visit a zoo you will think more deeply and look at the whole process – and your responses – with a different, more informed and more sophisticated eye.

Accessibly written, *American*

Zoo is light on sociological jargon – in fact, I could have done with more theoretical interpretation and a richer description, in particular when looking at how zoos developed historically and the recent surge in female staff in US zoos. It should be required reading for students of conservation biology, anyone thinking of working in a zoo and for all of us who visit these amazing, infuriating institutions.

Grazian’s book is inspiring. He makes the reader repeatedly reflect on whether there might be better ways of educating the public and contributing to wildlife conservation. Thinking about such things should be part of what a zoo does: to my mind, if you do not leave a zoo confused and conflicted, as well as inspired, it has not done its job properly. ■

Matthew Cobb is professor of zoology at the University of Manchester, UK



In whose best interests is it to have polar bears in zoos?

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Faculty Insider Feature, Part 1



Faculty Positions in Biochemistry and Molecular Biophysics

The Department of Biochemistry and Molecular Biophysics at Washington University School of Medicine invites applications for several tenured/tenure-track faculty positions at the level of Assistant/Associate/Full Professor. Successful candidates will have established a strong record of research. Applicants seeking tenured positions must have a strong record of external funding.

Outstanding individuals working in any area of biochemistry and molecular biophysics are encouraged to apply. The candidate's research should be aimed at addressing fundamental questions related to molecular mechanisms of biological or biomedical relevance. Current research in the department spans a wide range of topics including computational biology, membrane proteins, molecular motors, nucleic acid / protein interactions, protein structure, enzymology and signal transduction. Additional information about the department is available at <http://www.biochem.wustl.edu>. Washington University has a highly interactive research environment with vigorous interdisciplinary graduate and medical scientist training programs.

Applicants should email their curriculum vitae, brief description of their research interests, and contact information of three individuals to the Search Committee at bmbsearch@biochem.wustl.edu. The committee will request letters from these individuals as necessary.

Completed applications will be reviewed on a rolling basis, starting immediately. For full consideration, applications should be received by December 1, 2015.

EOE/Minorities/Vets/Disabilities. The School of Medicine at Washington University is committed to finding solutions to global health problems, including ones that affect minority and disadvantaged populations.

Harvard University Faculty of Arts and Sciences, Cambridge, MA Department of Chemistry & Chemical Biology TENURE-TRACK PROFESSOR

Position Description: The Department of Chemistry & Chemical Biology seeks to appoint a tenure-track assistant professor in the open field of chemistry and chemical biology. The appointment is expected to begin on July 1, 2016. The tenure-track professor will be responsible for teaching at the undergraduate and graduate levels.

Basic Qualifications: Doctorate or terminal degree in chemistry or related discipline required by the time the appointment begins.

Additional Qualifications: Demonstrated excellence in teaching is desired.

Special Instructions: Please submit the following materials through the ARIeS portal (<http://academicpositions.harvard.edu/postings/6320>). Applications must be submitted no later than October 15, 2015.

1. Cover letter
2. Curriculum Vitae
3. Teaching statement (describing teaching approach and philosophy)
4. Outline of future research plans
5. Names and contact information of 3-5 references (three letters of recommendation are required, and the application is complete only when all three letters have been submitted)
6. List of publications

Harvard is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law.

Contact Information: Helen Schwickroth, Search Administrator, Department of Chemistry & Chemical Biology, Faculty of Arts and Sciences, Harvard University, 12 Oxford St., Cambridge, MA 02138. Phone: (617) 496-8190.

Contact Email: Helen@chemistry.harvard.edu



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The UAB Department of Genetics seeks applicants for a faculty position in the field of biochemical genetics. The Department of Genetics has an established biochemical genetics program consisting of clinical diagnostic and laboratories, and a clinical consultation service. Faculty rank will be Assistant or Associate Professor and may be either tenure or non-tenure earning. UAB faculty appointment and compensation are commensurate with qualifications and experience. Qualified candidates will have M.D. and/or Ph.D. credentials, and be board certified in Clinical Biochemical Genetics or Medical Biochemical Genetics.

This individual will be Director of the Biochemical Genetics Laboratory, and will also be responsible for teaching, research and/or clinical pursuits. Prior experience should include managing and interpreting biochemical lab results including standard biochemical testing and lysosomal disease screening and testing. Applicants with research interests will have demonstrated ability to conduct significant independent research, and a successful track record of grant funding.

UAB is an Equal Opportunity/Affirmative Action Employer committed to fostering a diverse, equitable and family-friendly environment in which all faculty and staff can excel and achieve work/life balance irrespective of race, national origin, age, genetic or family medical history, gender, faith, gender identity and expression as well as sexual orientation. UAB also encourages applications from individuals with disabilities and veterans.

A pre-employment background investigation is performed on candidates selected for employment.

The University of Alabama at Birmingham offers an excellent benefits package including medical/dental insurance and dependent tuition. Interested applicants please send curriculum vitae including references, and a description of your teaching, clinical or research portfolio to:

Bruce R. Korf, M.D., Ph.D.
Professor and Chairman
c/o Dee Blakely-Stoudermire
UAB Department of Genetics
720 20th Street South, KAUL 230
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KANSAS STATE UNIVERSITY

RESEARCH ASSOCIATE KANSAS STATE UNIVERSITY DEPARTMENT OF PHYSICS

The PER group at Kansas State University invites applications for a research and teaching postdoc in physics education research to start in Fall 2015. You will work with our team on issues of enculturation and assessment across the four-year physics curriculum, looking at how students make connections across coursework and how to promote good teaching. Additionally, you will teach in introductory physics classes and contribute to mentoring graduate students and undergraduate researchers.

You must have earned a PhD or EdD in physics, science education, or a related field by the date of appointment and be eligible to teach physics courses. You will be given preference if you have completed a dissertation in qualitative or quantitative physics or science education research. The successful candidate will demonstrate outstanding teaching and mentoring skills, excellent writing skills, and the ability to work collaboratively with diverse students, researchers, faculty, and staff.

The initial appointment will be for one year with a possible second year term appointment contingent upon performance and availability of funding.

The PER group at KSU has two faculty members, two postdocs, five graduate students, and three undergraduates, as well as faculty affiliates in physics and other STEM fields. The Physics Department is a friendly and supportive environment for PERers. Manhattan is a vibrant and affordable community situated in the beautiful Flint Hills region of Kansas.

Candidates should submit a packet including: a letter of application; vita including a list of publications; and a research statement describing the candidate's relevant background, interests in physics or science education research, and the relation of the position to the candidate's long-term goals. Send your packet to the PER group's search email, persearch@phys.ksu.edu, in PDF format. You should also arrange for three letters of reference to be sent to the above address. If you have questions about the position, the research group, or the institution, contact Dr. Ellie Sayre at esayre@ksu.edu.

Screening of applications will begin August 15, 2015 and continue until position is filled.

Kansas State University is an Equal Opportunity Employer of individuals with disabilities and protected veterans. Background check required.



THE UNIVERSITY
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MANAGING DIRECTOR Center for Sustainable Nanotechnology PVL 83199

The Department of Chemistry of the University of Wisconsin-Madison is recruiting for a Managing Director in the Center for Sustainable Nanotechnology (CSN.) The Director works with the Center Director and the CSN Executive Committee and is responsible for actively directing and coordinating scientific research and additional integrative activities at multiple institutions to achieve the center's goals. A Ph.D. in Chemistry or related field experience is required. This is a full-time position with an anticipated beginning date of **October 1, 2015**. There will be a minimum twelve-month evaluation period.

Specific duties of the Director may include: Overseeing general operation of the center; establishing and implementing center-wide policies and procedures that will maximize the effectiveness of the center's scientific objectives and associated integrative activities; oversee center-wide finances (including multiple sub-contracts) and develop financial plans for the center; ensure that Center programs and activities are compliant with federal/state regulations; interface directly with federal agency personnel to meet reporting requirements and to communicate the center's scientific progress and objectives. This will include identifying high-impact scientific results and translating into language appropriate for program managers and policymakers.

For additional information, please go to:

http://www.ohr.wisc.edu/Weblisting/External/PVLSummary.aspx?pv1_num=83199

Additional information on the Center for Sustainable Nanotechnology is available at

<http://susnano.chem.wisc.edu>

Please submit a letter of interest, curriculum vita and 3 references referring to **PVL 83199** to **Dennis Reece at the Department of Chemistry, University of Wisconsin-Madison, 1101 University Ave., Madison, Wisconsin 53706-1322.**

To guarantee full consideration, all materials must be received by **September 15, 2015**.

The University of Wisconsin is an equal opportunity and affirmative action employer; applications from qualified women and minority candidates are encouraged. Unless confidentiality is requested in writing, information regarding the identity of the applicant must be released on request and there are deadlines for disclosure. Finalists cannot be guaranteed confidentiality. A background check may be required prior to employment

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M | LSA COMPLEX SYSTEMS UNIVERSITY OF MICHIGAN

ASSISTANT PROFESSOR in Complex Systems

The Center for the Study of Complex Systems (CSCS) at the University of Michigan invites applications for a tenure-track position of Assistant Professor of Complex Systems. Candidates at a more senior-level will also be considered. The appointment will begin **September 1, 2016**. This is a University-year appointment. Information about the Center can be found here: <http://www.lsa.umich.edu/cscs>.

Required Qualifications

Candidates must have a demonstrated research agenda focusing on complex systems. This may involve theoretical or applied research on complexity, including (but not limited to) mathematical and computational models in areas such as networks, computation, emergence, large events and robustness or applications where complexity lies at the core such as quantitative modeling of social systems, soft condensed matter physics, evolutionary or ecological dynamics, epidemiology and disease transmission, artificial life, neuroscience, and cognition. Preference will be given to candidates with a track record of working across disciplines.

How to Apply

All application materials must be uploaded onto this website:

<https://complexsystems-lsa.applicantstack.com/x/apply/a2guio5y9cxr>

The position is based in CSCS but will be a joint appointment with another department. In the cover letter, candidates should identify one or more partner departments at the University of Michigan suitable for such a joint appointment. Applicants must submit: a current CV, statement of current and future research plans, a statement of teaching philosophy and experience, evidence of teaching excellence (if any) and one writing sample. At least three letters of recommendation are required and must be uploaded onto the same website. Applications will be reviewed starting **October 1, 2015**. Applications will be accepted until the position is filled.

Women and minority candidates are encouraged to apply. The University of Michigan is an equal opportunity/affirmative action employer and is supportive of the needs of dual career couples.

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Scientists in any field who have a doctorate in the area of the proposed project (by December 2014) and at least two published articles or monographs are eligible to apply for a Radcliffe Institute fellowship. The stipend amount of \$75,000 is meant to complement sabbatical leave salaries of faculty members. Residence in the Boston area and participation in the Institute community are required during the fellowship year.

Applications for 2016-2017 are due by October 15, 2015.

For more information, please visit www.radcliffe.harvard.edu or email sciencefellowships@radcliffe.harvard.edu.



THE UNIVERSITY OF
CHICAGO

Assistant Professor of Chemistry

The Department of Chemistry at The University of Chicago invites applications from outstanding individuals for the position of Assistant Professor of Chemistry. This search is in the areas broadly defined as inorganic, organic and physical chemistry. Applicants must apply online to the University of Chicago Academic Career website.

Inorganic chemists apply to <http://tinyurl.com/nq59kgr>, Organic <http://tinyurl.com/oxvy7n8>, and Physical <http://tinyurl.com/py98uyk>.

Please apply to one search only. Applicants must upload a cover letter, a curriculum vitae with a list of publications, a succinct outline of research plans and a one page teaching statement. In addition, three reference letters are required. At the time of hire the successful candidate must have a Ph.D. in Chemistry or a related field. Joint appointments with other departments are possible. Review of applications will continue until all positions are filled.

Referral letter submission information will be provided during the application process.

All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, age, protected veteran status or status as an individual with disability.

The University of Chicago is an Affirmative Action / Equal Opportunity / Disabled / Veterans Employer.

Job seekers in need of a reasonable accommodation to complete the application process should call 773-702-5671 or email ACOppAdministrator@uchicago.edu with their request.



Call for Applications Chair,

Department of Medical Biophysics

The Schulich School of Medicine & Dentistry, at Western University, is inviting applications for the position of Chair in the Department of Medical Biophysics.

As Canada's first Department of Biophysics, the Department has grown to become one of Canada's leading centres for medical biophysics research with approximately 20 primary faculty members and over 70 actively collaborating cross appointed faculty leading internationally recognized research programs in medical imaging, microcirculation, computational modelling, biomechanics, and cancer. The department is the academic home to both undergraduate and graduate programs, including CAMPEP accreditation. It draws on a rich city-wide infrastructure incorporating two research Institutes, three hospitals, and five University Faculties. Research programs benefit from close collaborations between clinical and basic science faculty, with unique training programs in diverse fields.

The successful candidate should have a demonstrated track record of leadership and research and teaching excellence with a proven reputation for effective interpersonal and administrative skills. The new Chair will facilitate collaboration and be expected to support the research, educational and interdisciplinary initiatives of the Department. The successful candidate will build on the strength and forward momentum of the Department's graduate and undergraduate programs and promote the development of new initiatives in research, scholarship and education. He or she must have a PhD, MD, DDS or equivalent, and will receive a tenured academic appointment at the level of Associate or full Professor. Candidates with a research program complementing existing research strengths are particularly encouraged to apply. The position of Chair is for a five-year term, renewable.

Western University is located in London, Ontario, with a metropolitan census of 530,000. As Canada's 11th largest city, London boasts an extensive educational and health care community. With full time enrollment of 32,000, Western graduates students from a range of academic and professional programs. Further information about the Schulich School of Medicine & Dentistry and Western University can be found at www.schulich.uwo.ca, and <http://www.uwo.ca>. Western's Recruitment & Retention Office is available to assist in the transition of successful applications and their families. Details about the Department of Medical Biophysics can be found at <http://www.schulich.uwo.ca/biophysics/>.

Interested candidates should submit a CV outlining their research, teaching, and administrative experience and interests, including future directions, together with the names and addresses of three referees to:

**Dr. Michael Strong, Dean
Schulich School of Medicine & Dentistry
Room 3701A, Clinical Skills Building
Western University
London, Ontario N6A 5C1
FAX: (519) 850-2357
selection.committee@schulich.uwo.ca**

Please ensure that the form available at <http://www.uwo.ca/facultyrelations/faculty/Application-FullTime-Faculty-Position-Form.pdf> is completed and included in your application submission.

**Applications will be accepted until the position is filled.
Review of applicants will begin after September 30, 2015.**

Positions are subject to budget approval. Applicants should have fluent written and oral communication skills in English. All qualified candidates are encouraged to apply; however, Canadians and permanent residents will be given priority. Western University is committed to employment equity and diversity in the workplace and welcomes applications from all qualified individuals, including women and men, members of visible minorities, aboriginal persons, persons with disabilities, and persons of any sexual orientation or gender identity.



BOTANICAL T-32:

Training in Botanical Approaches to Combat Metabolic Syndrome

Postdoctoral fellowship on an NIH Institutional Training Grant entitled *Botanical Approaches to Combat Metabolic Syndrome*, seeks MD or PhD with strong scientific credentials and interest in animal or human metabolic research using botanicals. Fellowship provides up to three years of funding for training in lab skills and coursework necessary for establishing an independent research career. Must be a US citizen or green card holder.

This training program is sponsored by the National Center for Complementary and Integrative Health (formerly NCCAM) and is located within the Botanical Research Center (BRC) on the campus of Pennington Biomedical Research Center in Baton Rouge, Louisiana.

T32 postdocs will work toward enhancing research interactions between botanical characterization and molecular/genetic/physiologic approaches in both the basic science and clinical research areas. Trainees working in the laboratories of our basic and clinical scientists will benefit from collaborative research with botanical scientists. Learning about multiple areas of metabolic research and how botanicals interact and influence metabolic and cellular pathways will likely promote creativity and inspire trainees to transcend the boundaries that limit current research. We want our trainees to gain exposure to at least two specialty areas (e.g., genetics of metabolic syndrome, molecular regulation of insulin action, biochemical botanical characterization, botanical therapeutics) as we anticipate this will encourage future interdisciplinary research efforts needed to understand this complex and challenging syndrome.

** NIH requires applicants to be US citizens or have resident alien status for this training program.*

For more information please visit:
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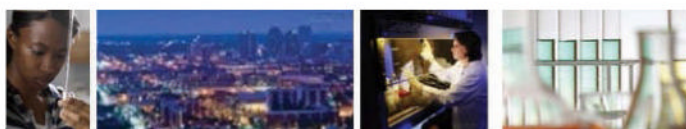
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EDITOR'S PICK



I watched my local glacier collapse

From Doug Scott

In your article reporting work by climate scientist James Hansen, he points out the risk of sudden sea level rise due to tidewater glaciers collapsing in decades rather than centuries (1 August, p 9).

His work has been criticised, but most of his critics don't understand the distinction between melt and collapse. They don't appreciate that glacial collapse has already happened to the Columbia glacier in Alaska and the Thwaites and Pine Island glaciers in West Antarctica.

In 1977 I moved to Valdez in Alaska, 27 kilometres from the terminus of the Columbia glacier. It was a large tidewater glacier, 550 metres thick and with an area of 1100 square kilometres – about the size of New York City and higher than the Empire State Building. Watching it calve 8 cubic kilometres of icebergs a day was a major tourist attraction. It attained further notoriety in 1989, when the Exxon Valdez ran aground avoiding one of those icebergs, causing a major oil spill.

Now, just 38 years later, all that is left of the Columbia glacier is two small branches.

I am a mathematician, not a climate scientist. Having seen my local glacier collapse so quickly, I share Hansen's concerns. Guildford, Surrey, UK

To read more letters, visit newscientist.com/letters

Giving birth under pressure

From Sarah Snuggs

Michel Odent raises some interesting questions around whether some women might find childbirth easier “in a small, dark, warm room, with... one midwife... knitting” (4 July, p 26). I would be interested to read any evidence supporting his theory, that women's capacity to give birth is repressed by neocortical activity, one source of which could be other people present in the room.

Wim Van Lerberghe and Vincent De Brouwere have estimated that 1500 in 100,000 unassisted births result in mortality, while death rates can be as low as 5 in 100,000 in countries where medical intervention is routine. Meanwhile, a survey published in the *British Medical Journal* in 2010 found no evidence to suggest that low-risk women were given caesarean sections inappropriately in the UK.

In our society women are often under immense pressure to deliver babies naturally, and many are led to feel they have “failed” if they do not do so. London, UK

C-sections, choice and risks

From Beverley Lawrence Beech, *Association for Improvements in the Maternity Services*

You report concerns that an advice leaflet for pregnant women spells out the risks of caesarean sections while it avoids mention of the risks of vaginal birth (25 July, p 5). But the World Health Organization has stated that there is no health improvement for either mother or baby when C-sections exceed 10 per cent of births in a population.

At the moment, the rate of caesareans in the UK exceeds 25 per cent. Those concerned

about risks around birth should investigate the risks of C-sections. Surbiton, Surrey, UK

The editor writes:

■ The WHO's position is contested, because of a lack of evidence that lower C-section rates are linked with lower mortality; in fact, countries with higher C-section rates have lower mortality. Aiming for vaginal birth may lead to an emergency C-section, which has much higher risks than either a planned C-section or a vaginal birth.

From Hester Mannion

It is still the general feeling in obstetric practice that a caesarean section poses certain risks to the mother but relatively few to the baby. However, choosing to surgically remove a baby from the uterus might carry with it some long-term problems. The baby misses out on the physiological environment created by natural labour: the complex cascade of hormonal events associated with the process of a contracting uterus and passage down the birth canal, as well as circulating oxytocin. As our understanding of epigenetics grows we could find a big impact.

We may find that the butterfly wingbeats of our personal choice leave our great-grandchildren weathering a hurricane. But by then, of course, it will be too late. Swansea, UK

Don't forget about heating

From Christopher Jessop

Your article on developments in battery technology was timely. (25 July, p 20). In the same issue your interview with Malte Jansen about German progress towards 100 per cent renewable power (p 17) surely made any Briton long for a UK energy policy with substance. However, it must be stressed that we need a policy for energy – not just for electricity.

When UK politicians and media say “energy” they nearly always mean “electricity”; yet heating buildings and water accounts for a large proportion of the UK's gas and oil consumption. So to reduce our carbon emissions, we need massive-scale replacement of boilers and storage heaters. In rural areas we could switch to heat pumps. Converting buildings in urban areas to district heating – served by decentralised combined heat and power units – would be far “greener” than out-of-town power stations that dump their waste heat into cooling towers.

Unfortunately, both methods are ruled out by investment-averse decision makers. And isn't “austerity” an excellent excuse for choosing equipment that is cheap for firms to buy and expensive for householders to run? Marloes, Pembrokeshire, UK

From Geoff Russell

Malte Jansen seems proud of the fact that by 2050 Germany will reach the same level of clean electricity production with renewables that France achieved in about 15 years with nuclear. I thought climate change was an urgent problem? St Morris, South Australia

The editor writes:

■ We asked Malte Jansen about nuclear power, but his answer was cut for space. He said that the process of digging uranium ore and making fuel rods is itself highly energy intensive, and since nuclear plants can't be turned rapidly on and off, they hinder the integration of renewable sources.

We should seek real energy security

From Emily Cox

Paul Younger writes that energy security seems to have been “forgotten” by those who oppose fracking for shale gas in the UK (11 July, p 24). Unfortunately, the

f “Bad news should come from a person in a supportive environment, not a strip of plastic”

Marie Ayres responds to our report of a test kit that could predict miscarriage (15 August, p 13)

article perpetuates the myth that reducing fuel imports automatically improves energy security. Energy security is a complex issue and cannot be simplified to metrics such as “reducing imports”. There is no evidence that imported fuels are less secure than domestic ones.

The vast majority of energy security problems in the UK have had domestic causes, for instance industrial action or the weather. Moreover, the UK has a highly secure imported gas supply, almost entirely from Norway, Belgium and the Netherlands. Initial attempts to frack, on the other hand, have led to widespread opposition and disruption, and hence costs and uncertainty for investors.

I am not opposed to fracking per se. As Younger points out, concerns about groundwater contamination have very little empirical basis. Moreover, US coal production has recently dropped, suggesting that US shale gas may be exerting downward pressure on global emissions.

Tax receipts from UK shale gas could benefit the Treasury. This is

where the potential benefits lie, not in vague claims about “energy security”.
Brighton, UK

Government worse than climageddon?

From Markus Eymann

Robert Gifford missed one of the family of “dragons” that stop people thinking about climate change (11 July, p 28). It is fear of big government.

The “logic” goes like this: climate change is a large-scale problem. The only institution big enough to tackle a problem on this scale is government. If you admit that climate change is real, you give government the power to implement a massive programme of social reorganisation to create a society that isn’t dependent on fossil fuels.

A government with this kind of power is, to those who hold this view, more threatening than climate change. So they can’t admit that climate change is real or caused by human activity. This

ideology is exemplified by the joke that environmentalists are like watermelons – green on the outside but red (communist) on the inside.

Edmonton, Alberta, Canada

There’s a fly in the longevity ointment

From Morag Perrott

Clare Wilson presents the fascinating fact that the action of the diabetes drug metformin contributes to a longer life (11 July, p 8). If older non-diabetics took the drug, they too could benefit from a lower incidence of heart disease and cancer.

Great! What isn’t mentioned, however, is that metformin has been linked to vitamin B12 depletion, a serious issue as it can lead to pernicious anaemia. Diabetics are known to have a higher incidence of damage to the peripheral nervous system and may be at greater risk of dementia.

Personally I would rather take my chances with a diet low in sugar and refined carbohydrates,

plenty of exercise and enjoying life as much as possible.
Darowen, Powys, UK

Talk about cash machines

From Butch Dalrymple-Smith

In your article “Slime-mould economics” you seem to express surprise that economic inequality is spiralling (25 July, p 38).

But when muscle power and brainpower are being replaced by machines, it seems obvious to expect that the machines’ owners will rapidly become wealthier than those whose labour is being replaced.

La Ciotat, France

Trees are the answer, again

From Barry Cash

Anthony Castaldo says we need a “cheap solar-powered device that can produce neat carbon pellets by the megaton” (Letters, 1 August). The machines are called trees and they store carbon in chipboard and paper. Instead of recycling or burning these products, I suggest we bale them up and cover them in thick recycled plastic – there seems to be quite a bit around that we don’t reuse. Then all we need to do is store the bales somewhere where they won’t be damaged.

I suggest old mines or quarries in the UK, deserts elsewhere, Antarctica – or, as he suggests, the bottom of the sea.

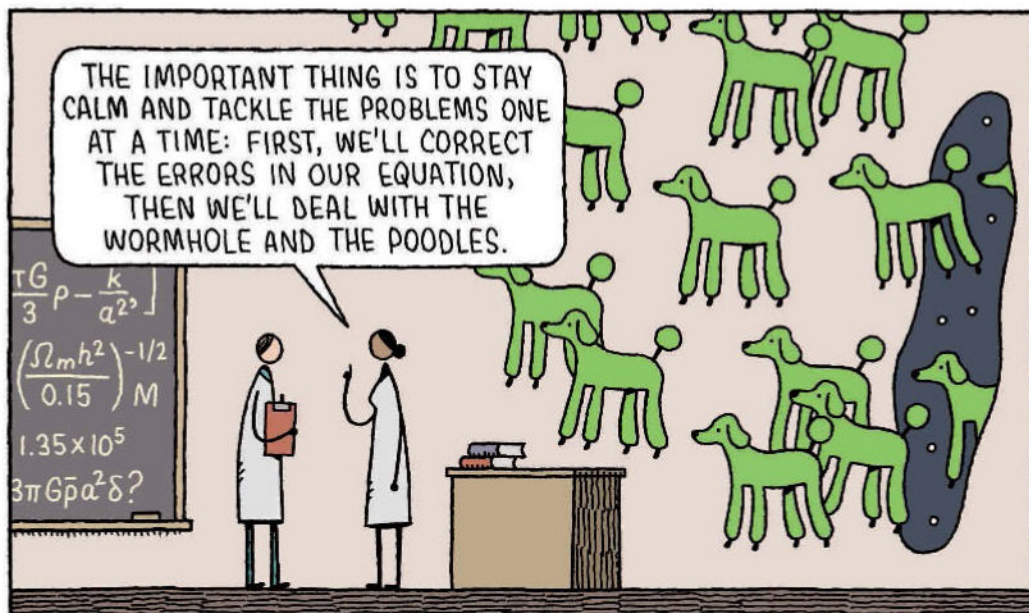
Bristol, UK

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TOM GAULD





VETERAN TV presenter Noel Edmonds is sleeping soundly at night after spending £2000 on a computerised yoga mat that recalibrates his electromagnetic fields. Edmonds shared the good news on Celebrity Radio, where he explained that phones and Wi-Fi are covering us all in the wrong sorts of electromagnetism, assuring host Alex Belfield “the biggest problem we have is not Ebola, it’s not AIDS, it’s electrosmog”.

That miracle mat is the EMPPad, which promises a suite of “profound” health benefits such as better sleep, reduced stress, and, alarmingly, a 500 per cent increase in cellular energy.

To achieve this, the manufacturers claim that the EMPPad “produces an electromagnetic pulse at an intensity and frequency which mimics the Earth’s magnetic field”. Handy for astronauts, we presume, but rather redundant for Earth-bound folk.

READERS may recall that Noel Edmonds previously baffled audiences with talk of “cosmic ordering”, a type of wishful thinking in which the cosmos will fulfill your desires, if you only ask.

This was accompanied by *Positively Happy*, a book in which the multi-millionaire “embarks on a journey to discover a scientific explanation for his enhanced state of well-being”. Edmonds concluded that the answer lies in a positivity formula of “scientifically proven elements” in the form of abstruse questions such as “Do you trust your tap water?” and “How well do you treat your villi?”.

You can even file your astronomical demands online at the Cosmic Ordering Site (bit.ly/NScosmic). Much as Feedback is tempted to ask the heavens for an end to this sort of fruitlooper, we can’t in good faith rid the world of something that brings so much genuine happiness to Noel Edmonds, and, in a roundabout way, to many of us as well.

FOR some weeks, correspondents to the Letters page have wondered how the average lifetime number of sexual partners could be 12 for men and 8 for women, as reported in *New Scientist* (27 June, p 34).

The Letters editor has put to bed these discussions, but Feedback is sure the assembled minds here can offer some ingenious hypotheses.

David Parlett suggests that the figures make perfect sense if the number of sexually active men and women is mismatched. “If there were a community of 12 women and 8 men, and each possible heterosexual pairing occurred at one time or another,” he writes, “then the women will each have had an average of eight partners and the men an average of twelve. Problem solved.”

MEANWHILE Anne Miller suggests: “Those who say that it’s impossible for men to have more lifetime partners than women neglect the implications of population growth.” Given that men seem to prefer younger women, and a growing population has more young than old, Anne reasons “it is mathematically straightforward for them to have significantly more lifetime partners than women do”.

Finally, Rory Allen writes to identify two explanations for the discrepancy. The first being that men are more willing to take part in same-sex encounters compared with women, while the second is that men are simply more willing to exaggerate. In truth, says Rory, “these numbers tell us more about the inaccuracy of self-reported statistics than they do about sexual activity”.

CHECKING our inbox, we find yet more ideas for renaming contactless cards. S.J. Courtney astutely points out that it would make more sense to name these cards for what they do, rather than what they don’t. “Since the user simply waves them over the reader, I suggest they be called wave-overs, possibly spelled wavovers.”

Avoiding the dreaded combination of Greek and Latin, Mike Frederick writes with a suggestion that is “entirely Latin and appealing to non-classical scholars to fit the current vogue for portmanteau words”. We rather like his solution: “nontact”.

THE use of pseudoscientific equations as an advertising gimmick continues to evolve. Feedback previously mulled the unexplained letters scattered like runes in M&C Saatchi’s “holy grail” of marketing (25 July).

Now Anchor Cheddar advances the field again with a “formula for richness” that seeks to quantify the value in our lives through the mysterious interaction of letters coding for attitudes toward success, family and perfection, among others.

Happily enough, the equation finds that those with the richest lives aren’t wealthy financiers but married couples on middle incomes and other groups that fall into Anchor Cheddar’s target market. Fancy that.



POLICE in Leicestershire, UK, have been investigating burglaries only at even-numbered homes, reveals the *The Telegraph*. The scheme is said to have reduced workload with no effect on convictions or public satisfaction (though Feedback wonders if only even-numbered homes were sampled in surveys on police satisfaction).

Five more counties are eyeing a similar cost-saving measure. This presents an interesting dilemma for would-be burglars: if you suspect the local force has such a policy in effect, is it better to stick to odd or even-numbered homes, or spread your risk by alternating between the two?

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week’s and past Feedbacks can be seen on our website.

Duncan Gaskin is told by *The Mirror* that eating spicy food makes him “10% less likely to die”. “Pass me a Korma,” he says, “I might live forever!”

Hazy blaze

The worst sunburn I ever received was on a beach in Wales on a dull, misty day. I have holidayed many times on Greek islands in the height of summer but have never experienced sunburn like it. What could be the cause?

■ I doubt that your questioner used sunscreen on the Welsh beach, through being lulled into a false sense of security. After all, the sun wasn't visible and the low temperature would have meant there was less of a sense of burning. On the Greek islands however, I am guessing that they would have applied sunscreen liberally, and subsequently retreated to a suitable area of shade when too hot.

the snow and passed under the hem of my trouser legs.

UV radiation comes in three bands. UVA is the lowest frequency, with UVC being the highest and most dangerous, but fortunately it is blocked by ozone. The one that causes sunburn is UVB light.

In 2004, Australian researchers reported an increase of 40 per cent in the intensity of UVB radiation under broken clouds. Although counter-intuitive, this is just one of several studies suggesting that clouds enhance UV. Although the mechanism isn't clear, the effect appears to be maximised when high-altitude cirrus clouds refract UV and this light is reflected by low-altitude cumulus clouds. Hazy conditions accentuate the outcome.

UV-induced damage to DNA triggers the production of melanin, a photoprotective pigment that acts as a natural sunscreen to reduce further damage. Burning happens through high levels of exposure.

Exposure to UVB depends on several factors: the time of year (it is higher in summer); the time of day (with a peak at solar noon, when the sun is highest in the sky); altitude (UV levels increase by about 10 per cent for every 1000-metre rise in altitude); the amount of time spent outside; and latitude.

All other things being equal, one would expect greater exposure in Greece, which has an ultraviolet index of three compared with two for Wales.

Perhaps surprisingly, sunlight during the summer solstice is only about 20 per cent more intense in Greece than in Wales. But this can be trumped by cloud enhancement of UV or, if sunscreen is not applied in chillier climes, by the mistaken belief that sunburn is only a hazard on a sunny day.

Mike Follows
Sutton Coldfield,
West Midlands, UK

play here? Or could it be something else?

Lloyd Tregenza
Adelaide, South Australia

CLOCKWISE

Do all climbing plants such as my morning glory grow clockwise, and if so, why?

Roger Pither
Ottawa, Canada

MAP LAG

On ancient maps, India is usually portrayed as much smaller than it is nowadays. Sometimes it's perhaps only half the size. Surely mariners of the time could judge distances, especially along a relatively even coastline. What is the reason for the discrepancy?

T. L. Threlfall
Essex, UK

SHARP TASTE

Why do plants with berries often have thorns? Aren't such plants sending mixed messages? Why would they want to repel animals that would eat their berries and spread their seeds?

Marinus Lutz
Vancouver, Canada

POND SKIMMER

I have a garden pond that suffers from "pea-soup" algae. A thunderstorm recently flooded the nearby road, overflowing into my garden and the pond. The next morning the algae had gone. What was in the floodwater that managed to clear the algae?

Colin Carter
Marlborough, Wiltshire, UK

"In 2004, researchers reported a 40 per cent increase in the intensity of UVB under broken clouds"

Unfortunately for the skin, the ultraviolet (UV) radiation that led to the sunburn passed through the clouds. And the mist would have acted as a diffuser to ensure an even sunburn.

To make matters worse, the sand and sea would have acted as mirrors, reflecting some of this radiation back up – possibly onto skin unused to receiving much sunlight. This was certainly my experience on a visit to Jungfrauoch in the Swiss Alps: after less than an hour outside, I had sunburn above my boots where sunlight had reflected off

This week's questions

DOUBLE BUBBLE TROUBLE?

These mushroom "bubbles" developed about 15 minutes after I topped up a half-full container with more liquid soap (see photo). The fresh liquid seemed to bounce off the bottom of the container and then mushroom up. Are the principles of surface tension and drag outlined in earlier answers to "Bubble trouble" on 20 June at



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